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ORIGINAL ARTICLES

CANNING OF PEACHES AND PLUMS IN BALUCHISTAN

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THE canning of peaches is an important industry in the United States of America and Australia. Among the canned fruit of commerce, peaches occupy the first place. In California, the yellow clingstone varieties are preferred for canning since they have almost all the good qualities of a canning fruit. According to Cruess [1938], peaches for canning should be of a large uniform size, symmetrical shape, yellow colour, with close tender fibre, not coarse or ragged ; and should have good canning quality, i.e., should retain their form, size, flavour, colour and aroma during sterilization in the can. The pit should be small in order to give thick halves that do not flatten during heating. The fruit should ripen evenly from the surface to the pit and should not be softer at the pit than at the surface. Many of the freestone varieties of peaches, however, lack one or more of these desirable characteristics. In recent years, satisfactory methods have been developed for canning these also [Mottern and Neubert, 1940], [Caldwell and Culpepper, 1944], [Weldhens and Neubert, 1944].

Numerous varieties of peaches, both local and imported, are grown at the Fruit Experiment Station, Quetta. Local varieties are mostly of the clingstone type. They have white flesh which is soft and juicy and is easily bruised by handling. The imported varieties are the yellow clingstone peaches with firm yellow flesh and the freestone peaches with soft yellow or white flesh. A series of experiments were conducted for several years from 1938 onwards to can these several varieties of peaches. The scheme was financed jointly by the Imperial (now Indian) Council of Agricultural Research and the Baluchistan administration. The results of these investigations are recorded in this paper. A short account of the results obtained up to 1943 has already been published [Siddappa and Mustafa, 1946].

In addition to peaches, different varieties of plums, local as well as imported, are grown at the Fruit Experiment Station, Quetta and outside. The results of canning trials with these are also given in this paper.

Peaches

Material

The varieties of peaches used in the canning trials were obtained mostly from the peach variety plot at the Fruit Experiment Station, Quetta. A few samples of

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Now in Madras Agricultural Service

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white clingstone peaches were also purchased from the local orchards. A small consignment of the 6-A peach of the North West Frontier Province was also got. The fruit was picked at the canning-ripe stage when it was fully ripe, but firm.

Method

The canning machinery and the equipment installed at the Research Laboratory have been described by Siddappa [1942, 1]. A small galvanized tank fitted with a steam coil was used for heating the lye solution for peeling the peaches [Siddappa, 1942, 2]. In the case of the soft-ripe freestone peaches, the same tank was employed for steam-peeling also, slat-bottom wooden trays being used for arranging the fruit. Although the methods for canning peaches have been highly standardized, it is necessary to modify them to suit local conditions. Quetta being 5,540 ft. above sea level, water boils at 202°F. approximately. Times of sterilization which are accepted as standards in other countries are with reference to a boiling temperature of 212°F. of water in an open cooker and as such are not directly applicable under Quetta conditions. Process times had, therefore, to be increased. The methods employed for canning the different types of peaches are briefly as follows:

Selection of fruits

The fruit was picked at the firm-ripe stage of maturity. It was graded according to size and maturity. Inferior fruit was set aside for jam making. The fruit was washed in water and drained on trays.

Cutting and pitting

In the case of clingstone peaches, the fruit was cut round along the main suture and one half removed by twisting the fruit quickly between the palms of the two hands. Alternately, by inserting a spoon-shaped pitting knife from the stem end of the fruit and giving it a twist to cut the flesh round the stone, the fruit could be cut into two halves. The pit was then removed by the pitting knife. Freestone peaches were easily cut into halves and pitted by means of an ordinary stainless knife. Cutting and pitting is a slow process.

Peeling

(a) *By lye solution.* Lye-peeling was used to remove the skin. The halves were placed in wire baskets and dipped for 1-2 minutes in boiling two per cent caustic soda solution, after which they were rapidly rinsed in plenty of cold water to wash away the loosened skin and the excess alkali. In the case of the clingstone peaches, the lye-peeled halves had a glistening appearance and the peeled surface was quite smooth and slippery. After trimming, the peeled halves were graded according to size and colour and filled into cans. The white peaches had a tendency to turn brown after lye-peeling.

(b) *By steam.* Fully ripe soft peaches could not stand this drastic lye-treatment. They were, therefore, peeled by placing the cut halves in an inverted position on monel metal sieves arranged in tiers inside a galvanized tank fitted

with perforated steam pipes. The top of the tank was covered with a lid and the steam turned on for 3 to 4 minutes. The steam supply was then cut off. At this stage, the peel could be lifted in one piece from the steamed half of the fruit. In some cases, however, especially when the fruit was not fully ripe, the whole of the peel could not be removed easily and portions had, therefore, to be trimmed with a knife. Considerable trimming tended to spoil the appearance of the fruit. Steam-peeled fruit should not be handled much before filling into the cans.

(c) *By knife.* Almost all soft-ripe freestone peaches could be peeled with a knife, but the peeled fruit did not have the characteristic smooth appearance of the lye-peeled or steam-peeled fruit. Knife-peeling is, however, useful in the case of soft and fibrous fruit which cannot be satisfactorily peeled by lye or steam.

Syruping

After filling the fruit into the cans they were covered with 55° F. Brix. syrup at 175-180°F. for fancy pack, leaving ¼ in. headspace.

Exhaust and process

The filled cans were given a steam exhaust of 6 to 8 minutes at 185°F. to 190°F. and sealed immediately. The sealed cans were processed in boiling water in an open cooking tank for 30 minutes in the case of soft-ripe freestone peaches and 55 minutes in the case of firm-ripe clingstone peaches. These times were changed in a few cases for specific investigations. After processing, the cans were quickly cooled in running cold water to about 110°F., wiped dry and stored at room temperature.

Cut-out test

After different periods of storage, samples of the canned product were examined for vacuum, syrup density, texture, taste, flavour, etc.

Varieties of peaches for canning

A short account of the processes employed for canning and the results obtained with 14 important varieties of peaches has been published by Siddappa and Mustafa. Further details were given in the series of annual reports from 1938 to 1943 of the Canning and Fruit Preserving Research Scheme, Quetta. The important characteristics of all the varieties tested for canning quality are given briefly in this paper by classifying them suitably under the two main types, clingstone and freestone.

Clingstone peaches

White clingstone peaches. Local varieties of peaches are mostly of the clingstone type. The flesh is white to creamy in colour and is very soft and juicy. It does not stand the lye-treatment. The red portion near the pit turns pale blue in the can. The fruit has a marked tendency to break down during processing, rendering the covering syrup cloudy and unattractive. For satisfactory peeling by knife or hot lye the

fruit should be picked when it is firm-ripe. At this stage of maturity, the flavour will not have developed fully. The white clingstone peaches are not quite suitable for canning, although they are good for the preparation of squash or jam. They are large fruits (2-2½ fruits per lb.) and ripen towards the middle or end of August.

Yellow clingstone peaches. A large number of yellow clingstone peaches have been introduced from California and other places and some of these have done well at the Fruit Experiment Station, Quetta. Varieties like Sims, Gaume and Phillips cling have given excellent canned products.

Sims. This is a medium size peach of regular roundish shape. It ripens in late August or early September. The flesh is firm and pinkish yellow in colour. The stone cavity is small, bearing thick fleshy halves. The fruit is well suited for lye-peeling and gives an excellent canned product. An A-2½ can holds 9-10 halves.

Gaume. This is a clingstone peach of medium size which ripens towards the middle of September. It is similar to Sims and gives an excellent canned product. An A-2½ can requires 9-10 halves.

Phillips cling. This is a medium to large clingstone peach with deep yellow flesh which is firm and mildly sweet. Each fruit weighs 5-5½ oz. The stone cavity is free from any pink colour. In California and other countries, this peach along with another variety called Tuscan is considered to be one of the most important for canning. In Quetta, the fruit ripens towards the end of August, but when picked at this stage, the flesh is hard and the flavour is not fully developed. Even by the end of September, the flesh does not become sufficiently tender. By that time, however, the weather becomes quite cold and consequently, the fruit does not ripen properly even if allowed to remain on the tree. This variety is not, therefore, quite suited for local conditions, although the canned product is quite good.

Peaks. This is a medium size peach which ripens towards the middle of September. The skin is yellow with a red blush. The flesh is firm and deep yellow in colour and has a mild sweet taste. It gives a good canned product. It is, however, susceptible to frost.

Palora. This is a small to medium size peach (8 fruits per lb.) which ripens towards the middle of September. It has orange yellow flesh of good texture. The skin is yellow with patches of red spots. This peach resembles Sims in several respects and is a good canner.

White Heath. This medium sized yellow clingstone peach with red-spotted yellow skin ripens towards the end of September. The flesh is yellow and compact. It resembles the Phillips cling and is a fairly good canning variety. The stone, however, is large for the size of the fruit.

Halford. This is a small peach with a large stone inside, and ripens early in October only. The flesh is of deep orange yellow colour and firm texture. It gives a good canned product.

Varieties K. 1 and K. 2. These two are yellow clingstone peaches growing at the Fruit Experiment Station, Quetta. Their nomenclature is not definitely known. They ripen towards the third week of September. They are large peaches with

firm and compact flesh of bright yellow orange colour. The stone is rather large. The canned product has good taste and flavour. An A-2½ can requires 9-10 halves.

Freestone peaches

Yellow freestone peaches

Parvin. This local peach is a large freestone yellow peach with good taste and flavour. It ripens towards the middle of September. The flesh is rather fibrous and inclined to break during peeling and processing. The canned product is fairly good. This variety appears to be quite promising.

Elberta. This is an important freestone peach largely employed for drying and dehydration in California. It is of large size (3 in. × 2½ in. ; each fruit weighing about 5 oz.) and ripens towards the end of August. The flesh is of bright yellow colour. Much of the flesh in the stone cavity is of red colour. The fruit has excellent taste and flavour and is a good table peach. The edges of the fruit break down during lye-peeling. Recently, by employing the steam-peeling technique soft ripe freestone peaches have been successfully canned and popularized in America. When steam-peeled, Elberta gives a fairly good canned product.

Muir. This large freestone peach has fairly compact flesh of a deep orange colour. It is delicious in taste and resembles the Elberta in several respects. It, however, ripens late in the season, as late as October, when other varieties are over. It is not quite suitable for canning as the flesh breaks down considerably during peeling and processing.

Lovell. This freestone peach is small in size and ripens towards the middle of September. The flesh is light yellow, soft and juicy. During lye-peeling, it breaks down extensively rendering much trimming necessary. The canned product is, however, quite good.

Salway. This freestone yellow peach resembles closely the local Parvin. It ripens towards the middle of September. It gives a good canned product.

Strawberry and Curry. These two large freestone peaches (3 in. × 2½ in. size ; approximate weight of fruit 5 oz.) ripen towards the end of August. They are not quite suitable for large-scale canning.

6-A peach. This is a large freestone yellow peach (3 in. × 3½ in. size ; 2½ fruits to the pound). It is grown largely in the North West Frontier Province. It ripens towards the middle of July. Some fruits were got for canning trials. The flesh is yellow with much red in the pit. In plain cans the red portion in the pit turns brown. It is, therefore, desirable to trim it off completely. The fruit is well suited for steam-peeling. The lye-peeled fruit is rather rough and has a broken appearance and poor flavour.

White freestone peaches

Babcock. This is a fairly large freestone American white peach which ripens early in August. The flesh is compact with only a small red portion in the pit.

The firm-ripe fruit, stands the lye-treatment quite well and gives a good canned product. The trees of this variety bear heavily.

Lukens honey. This is a medium size freestone white peach which ripens towards the middle of August (2 in.$\times$2 in. size ; 6-7 fruits to the pound). It is regular and round in shape. The flesh is of creamy white colour and is rather fibrous and juicy. It has a sweet taste and a mild flavour. Just like Babcock, it gives a good canned product.

Selection of varieties for canning

By proper selection of these varieties which ripen at slightly different periods of the fruit season, the peach-canning season can be spread over 8 to 9 weeks, which is highly desirable for the success of the industry.

Effect of stage of maturity on the canning quality

The quality of the final canned product is determined to a large extent by the stage of ripeness at which the fruit is picked. A few experiments were carried out during 1938 to study this in the case of Phillips cling. The results are given in Table I. This variety ripens over a long period and does not ripen fully even towards the end of September, when the cold weather sets in. Only fully ripe but firm fruit gives satisfactory texture in the canned product. Phillips cling, although an excellent canning peach, is not quite suited for propagation at Quetta, as it ripens late in the season when weather conditions are not favourable for proper ripening.

Cost of production

The classification of the various items of the cost of production of canned fruit under Baluchistan conditions has already been dealt with in considerable detail [Siddappa, 1942, 1]. In this case, it is, therefore, only necessary to give the cost due to each item. The figures are based on a production of 476 cans only during 1943 (Table II). A larger number of cans could not be packed as the yellow clingstone peaches which are the best suited for canning are found only at the Fruit Experiment Station, Quetta, having been introduced from abroad for experimental purposes. Further, due to war-time conditions, the cost of raw materials and labour had gone up much. The cost of production is, therefore, approximate and tentative only (Table III). Provision has been made for probable losses due to spoilage on account of inherent defects in cans, bad seams, etc. to the extent of five per cent. This will be about two per cent only under normal factory conditions. The fruit is the costliest item, while the can and the sugar occupy the next two places. The high cost of the fruit is due to the scarcity of the right type at present. When large plantations have sprung up, the cost of fruit is likely to come down. The cost of caustic soda is small (0·3 pie per can) since only 7 to 8 lb. of it are required to peel a ton of fruit. The cost of production of an A-2½ can of clingstone peach came to Rs. 0-12-1 which is reasonable in spite of the high cost of the several of the items of production. During 1944, the cost was Rs. 1-0-1 due to increase in the cost of fruit which was of poor quality resulting in much rejection. It will be much less during normal conditions.

TABLE I

Effect of stage of maturity on the canning quality of the Phillips cling peach

Experiment number	Date	Description of fruit	Preparation	Can used	Syrup strength Deg. Brix.	Exhaust	Process	Remarks
A-4	7 August 1938	Fairly ripe ; outside yellow, but still green in portions ; hard flesh ; no red flesh in stone cavity. Three fruits per lb.	Lye-peeled halves	A-2½ Lacquered	54	10 minutes at 190°F.	40 minutes in boiling water cooled quickly in cold water	8-10 halves per can. Colour improved on lye-peeling. Lye peeled halves did not darken for a long time. Cut out on 5 September 1938. Fruit rather hard being under-ripe ; syrup clear and bright ; can in perfect condition
A-5	29 August 1938	Fruit from the same tree as in Experiment A-4. Still under-ripe, although yellow colour fully developed. 10 fruit=3 lb. Weight of stones=4 oz., i.e., 8·3 per cent	do.	do.	52	10 minutes at 185°F.	do.	8-11 halves per can. Cut out. Fruit rather hard ; being still under-ripe, otherwise good
A-7	2 September 1938	Fruit from the same tree as in Experiment A-4 18 fruit= 5 lb. Fruit still unripe	do.	do.	do.	do.	do.	Cut out after 7 days. Fruit and syrup in good condition. Fruit rather tough. This variety appears to ripen over a long period. It has got almost all the desirable characteristics of a good canning peach
A-8	3 September 1938	Fruit left overnight from Experiment A-7 to study the effect of holding the picked fruit at room temperature	do.	do.	52·5	do.	do.	Fruit still hard in texture. Not much softening overnight
A-11	24 September 1938	Fruit firm still, although ripe. Flesh deep orange yellow in colour	do.	do.	51	do.	do.	Fruit fairly soft. Syrup clear. This is, however, the end of the fruit season. The peach ripens too late for the season

TABLE II

Canning of some important clingstone peaches (1943)

Experiment number	Date	Variety	Weight of fruit taken lb.	Weight of fruit rejected lb.	Weight of stones lb.	Weight of lye-peeled halves lb.	Syrup strength Deg. Brix.	Weight of sugar used lb.	Number of cans packed A-2½	Remarks
A-76	4 September 1943	Sims	206	2	24	159	55	100	153	11 halves per can. Cut out after six months. Syrup clear, 29·6° Brix. and 0·42 per cent acidity. Fruit in excellent condition. Inside of can only slightly feathered uniformly
A-77	7 September 1943	do.	123	4	12	95	do.	60	89	....
A-79	9 September 1943	do.	134	5	15	99	do.	65	97	....
A-78	8 September 1943	Gaume	85	3	10	63	do.	40	59	10 halves per can. Cut out after 6 months. Syrup clear and of 30·7° Brix. and 0·44 per cent acidity. Fruit in excellent condition. Can only slightly feathered
A-80	10 September 1943	Peak	108	4	12	80	do.	55	78	10 halves per can. Cut out after 6 months. Syrup clear and of 30·3° Brix. and 0·39 per cent acidity. Fruit in good condition. Can moderately feathered
		Total	656	19	73	496	—	320	476	

NOTE—Exhaust six minutes in steam ; process 55 minutes boiling water in all cases

TABLE III

Cost of production of an A-2½ can of peach

Item number	Particulars	Cost in pies	Per cent of total cost	Remarks
1	One A-2½ can (flattened can 33·98 pies and cost of reforming 3 pies)	36·98	25·43	Based on 1943 figures given in Table I
2	Fruit, 1·38 lb. at 3 annas per lb.	49·68	34·16	do.
3	Sugar, 0·67 lb. at Rs. 17-8-0 per 82 lb.	27·47	18·89	do.
4	Coal (40 cans per maund) at Re. 1 per md.	4·80	3·30	....
5	Labour (40 cans per man) at Re. 1 per day	4·80	3·30	....
6	Electricity charges	0·60	0·41	Approximate
7	Lye for peeling	0·30	0·21	do.
8	Label	3·54	2·43	....
9	Supervision	6·00	4·12	Worked out theoretically
10	Depreciation	4·00	2·75	do.
11	Allowances for probable spoilage due to defective seam, etc., at about 5 per cent of total cost	7·27	5·00	Kept high under experimental conditions, but should not exceed 1 to 2 per cent under normal conditions
	Total	145·44	100·00	

PLUMS

At Quetta, different varieties of plums, both local and imported, are grown. In order to test their suitablilty for canning and work out the cost of production a series of investigations were undertaken from 1938 onwards.

MATERIAL AND METHODS

According to Cruess [1938], the large sweet varieties o. white plums such as the green gage and the yellow egg are in the greatest demand for canning. The red and black varieties are seldom used. Of the dark plums the Victoria plum is canned largely in England. The Quetta plums such as *Alucha*, Quetta gage, *Peshawari Alu Bokhara* and yellow plum (No particular variety) and imported varieties like Yellow Drop, Gold, Late Orange, Santa Rosa, etc. grown at the Fruit Experiment Station or available in the market, were used. The fruit was picked when it had attained its maximum size and had its colour fully developed. Under-ripe or over-ripe fruit was discarded in order to avoid shrivelling, toughening and breaking down of the fruit during canning [Morris, 1933]. Much work on the canning of English plums has been done at the Campden Research Station (Glos.) England. The rejected fruit was utilized for making plum jam.

The equipment used was the same as for canning peaches. The fruit was sorted and graded by hand according to size and maturity. After washing, the fruit was filled into A-2½ size cans. Plain cans were used for all light coloured

varieties, while for dark purple plums like Santa Rosa lacquered cans were used. Cans with special heavy tin coating were not available. Lacquered cans were used for preventing discoloration, although it is known that lacquered cans are more subject to hydrogen swells and perforations than plain cans. Syrup of 45° Brix. was used. The exhaust was for 6-8 minutes in steam at 185°F. to 190°F., although Campbell [1937] recommends an exhaust of 8-10 minutes in water at 200°F. Process was for 25 minutes in boiling water followed by quick cooling to about 110 F. in water. The cans were stored for further observations. Data are given in Tables IV and V.

TABLE IV

Canning of plums (1943)

Experiment Number	Date	Variety	Weight of fruit taken lb.	Weight of fruit rejected lb.	Weight of sugar used lb.	Number of cans packed A-2½	Remarks
B-36	14 June 1943	*Alucha*	153	14	60	107	Good canned product
B-37	15 June 1943	Yellow drop	140	13	55	95	do.
B-38	16 June 1943	do.	375	25	140	250	do.
B-39	17 June 1943	Quetta gage	400	5	165	295	Excellent canned product
B-40	18 June 1943	Yellow drop	390	20	150	272	Good canned product
B-41	19 June 1943	do.	265	4	120	209	do.
B-42	21 June 1943	Quetta gage	220	20	85	146	Excellent canned product
B-43	22 June 1943	Yellow drop	395	30	150	260	Good canned product
B-44	24 June 1943	*Alucha*	146	18	55	89	do.
B-45	28 June 1943	K.1	304	49	110	174	do.
B-46	21 July 1943	*Peshawari*	12	1	5	9	Excellent canned product
B-47	do.	Gold	10	0·5	4	8	do.
		Total .	2,810	199·5	1,099	1,914	

Note.—Syrup 45° Brix. Exhaust 6-8 minutes. Process 25 minutes.

TABLE V

Cut out tests on canned plums (1943)

Sample number.	Date of canning	Date of cut-out	Variety	Vacuum in.	Gross weight (gm.)	Net weight of contents (gm.)	Drained weight of fruit (gm.)	Number of fruits per A-2½ can	Syrup strength (corrected to 63°F. Degrees Brix.)	Acidity of syrup as citricacid per cent	Appearance		Flavour	Appearance of the inside of the can	Remarks
											Fruit	Syrup			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
B-36	14 June 1943	9 March 1944	*Alucha*	9	975	831	531	41	25·6	1·78	Moderately firm.	Slightly cloudy	Aroma of almonds	Slight uniform feathering	Excellent canned product
B-40	18 June 1943	do.	Yellow drop	7	960	818	516	29	26·9	1·27	Firm	Moderately clear	do.	do.	do.
B-42	21 June 1943	do.	Quetta gage	7	982	839	544	19	26·2	1·39	do.	do.	do	Moderate uniform feathering	do.
B-45	8 July 1943	do.	K.I.	8	987	842	558	38	26·4	1·40	Moderately firm	Relatively clear	do.	Slight uniform feathering	Good canned product
B-46	21 July 1943	do.	*Peshawari*	12	938	797	504	31	26·5	1·36	Firm	Clear	do.	do.	do.
B-47	do.	do.	Gold	10	946	802	496	22	25·5	1·59	do.	do.	do.	do.	Excellent canned product

Varieties of plums for canning

A short accout of the canning qualities of different varieties of plums has been published by Siddappa and Mustafa [1946]. The varieties of plums tested are described under two main heads, white and coloured, which are further subdivided into local and imported.

White or light coloured plums

Local

Alucha. This small round plum (25 fruit per lb.) ripens towards the end of May. It is flattened slightly on either side of the suture. The skin is pale green in colour mottled with red. The flesh is soft and juicy and has a sweet taste. It gives a very good canned product.

Quetta gage. This variety is almost identical with green gage. It ripens towards the middle of July. It is a large, smooth round plum (8 plums to a lb.; $1\frac{1}{2}$-$1\frac{3}{4}$ in. in diameter). The skin is a mixed green and yellow. The flesh is thin and compact, yellow in colour and has a mildly acid taste and flavour. The juice has an acidity of 1·31 per cent as citric acid. The canned product is excellent.

Peshawari. This plum is of medium size and oblique globose shape. It ripens by about the middle of July. The flesh is pale white in colour and juicy and has a mild sweet acid taste. It is a good canner.

K.1. There are a few trees of yellow plum at the Fruit Experiment Station, and the variety is for the present named K.1. This plum resembles Gold to a considerable extent. It ripens by the end of June. It is a small plum, oblong round in shape and is golden yellow in colour. The flesh is firm and has light golden colour and acid taste. It gives a good canned product.

Yellow Alucha. These plums are not of any particular variety. They are generally small yellow plums and are good for canning.

Imported

Yellow drop. This is a medium sized round plum with a yellowish green colour (18 plums to the lb.; 18 stones weigh 1 oz. approximately). The flesh is golden yellow and has a slightly sweet acid taste. It ripens early in July. It gives a good canned product. An A-$2\frac{1}{2}$ size can holds about 22 fruits. At times, the skin has a tendency to peel off during processing.

Gold or Golden plum. This medium sized plum is roundish in shape and of golden yellow colour. It ripens by about the end of July. The flesh has a fine golden yellow colour. It is juicy, but firm, and has a slightly acid taste and flavour. It gives an excellent canned product.

Highly coloured plums

Local

There are a few distinct varieties of coloured plums available in the Quetta market during the fruit season. They have generally a bright purplish skin and

fibrous flesh which has a mildly acid taste. Their nomenclature is not definite. They are not quite suitable for canning.

Alu Bokhara. This is a large, soft and juicy plum (10 plums to the lb.; $1\frac{1}{2}$-$1\frac{3}{4}$ in. in diameter). It ripens towards the end of June. It is an excellent dessert plum, but is not quite suitable for canning.

Imported

Late Orange. This is a late plum which ripens towards the middle or the end of September. It is a large plum, slightly oval in shape and has orange yellow skin and flesh. The flesh is mealy and slightly acid in taste. The fruit is subject to considerable internal and external gumming, and there is consequently much waste during preparation for canning. The canned product is however, quite good. An A-$2\frac{1}{2}$ can holds 9-10 fruits.

Santa Rosa. When firm-ripe, this plum has a thick dark purplish red skin and pinkish flesh which has a scented flavour. It ripens towards the end of July. It is large in size and an A-$2\frac{1}{2}$ can holds 9-10 plums only. The juice has an acidity of 1·4 to 1·9 per cent as citric acid and a pH of about 3·0. When canned in a fruit-lacquered can using plain syrup as the covering liquid, the colour of the fruit passes on to the syrup. In plain cans, the fruit gets highly discoloured. The canned product has a characteristic musty flavour after some time. This plum is excellent for dessert purposes, but not for canning.

Rene claude Violet. This is a medium to large size plum (11 plums to the lb.) of a reddish purple colour, hard texture and smooth surface. It ripens by about the second week of August. It is a good canner.

Semi-commercial trials

During the (1943) season, further semi-commercial trials were carried out using selected varieties. The data are given in Table VI. The major items taken into consideration are the same as those already described by Siddappa [1942, 1]. In addition, allowance has been made for probable spoilage due to hydrogen swell formation, defective seam, etc. The cost of production of an A-$2\frac{1}{2}$ can of plums on the basis of a total production of 1914 cans comes to about twelve annas. This is high due to low production and abnormal war time conditions. During 1945, 11391 cans were packed. The cost of production came to Rs. 0-12-11. This high cost in spite of large scale production was due to the high cost of fruit and sugar. The average price of fruit was Rs. 12 to Rs. 15 only. On an average 77 A-$2\frac{1}{2}$ cans were got from a maund of fruit, which is very good yield.

Conclusion

Canning of plums in Quetta is a highly profitable undertaking Canning varieties of plums can be grown successfully.

TABLE VI

Cost of production of an A-2½ can of plum (1943)

Item number	Particulars	Cost in pies	Per cent of total cost	Remarks
1	One A-2½ can (flattened can 33·98 pies and cost of reforming 3 pies)	36·98	25·82	....
2	Fruit, 1·47 lb. at 3 annas per lb.	52·92	36·96	Average quantity of fruit worked out from Table I. Purchased at 3 annas per lb. from the Fruit Experiment Station Quetta
3	Sugar, 0·57 lb. at Rs. 17-8-0 per md. of 82 lb.	23·36	16·31	....
4	Coal (1 md. for 40 cans) at Re. 1 per md.	4·80	3·35	....
5	Labour (1 man for 50 cans) at Re. 1 per day	3·84	2·68	....
6	Electricity	0·60	0·42	Approximate
7	Label	3·54	2·47	....
8	Supervision	6·00	4·19	Approximate
9	Depreciation	4·00	2·79	Worked out theoretically
10	Allowance for probable spoilage due to defective seams, etc. (about 5 per cent of the total cost)	7·16	5·00	Kept high under experimental conditions, but should not exceed 2-3 per cent under ideal factory conditions
	Total	143·20	100·00	

Summary

Peaches

The results of a systematic investigation on the canning of several important varieties of peaches grown at Quetta are recorded in this paper. The local clingstone peaches, which are white and juicy, are not suitable for canning. Of the varieties introduced from California, Sims, Gaume, Peak and Palora give excellent canned products. The Phillips cling, although excellent for canning, ripens too late in the year to be recommended for propagation in Baluchistan.

Of the freestone peaches, yellow varieties like Elberta, Lovell, Salway and Parvin give fairly good canned products. Steam-pealing is preferable to lye-peeling in their case. Of the freestone white peaches, Babcock and Lukens Honey are suitable for canning.

The cost of production of an A-2½ can of clingstone yellow peach was Rs. 0-12-1·4, which is reasonable considering the high cost of the raw material and labour during 1943. It will be slightly less under normal working conditions.

Plums

Local varieties of white plums such as *Alucha* and Quetta gage are excellent for canning. Peshawari, K.1 and yellow *alucha* (mixed varieties) also give good

canned products. Of the imported white plums, yellow drop and Golden gage are excellent canners.

Highly coloured varieties of local plums like *Alu Bokhara* are not suitable for canning. Of the imported coloured varieties tried, Late Orange and Rere claude Violet gave good canned products, while, Santa Rosa was found unsuitable for canning.

Plain cans were suitable for canning white or light coloured plums. Lacquered cans were necessary to prevent discoloration in the case of highly coloured plums.

The canned product kept well for over 18 months. In the 1943 pack, there was not any serious spoilage.

The cost of production of an A-2½ can of plums was Rs. 0-12-0 in 1943 and Rs. 0-12-11 in 1945.

The major items of cost were fruit, container and sugar.

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REGISTRATION OF IMPROVED WHEAT VARIETIES IN INDIA

I. THE NEW PUSA WHEATS

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In view of the increasing number of improved crop varieties under cultivation in India, the need for a standardized description bringing out their economic qualities and distinguishing characters is evident. Such precise information if published, would be useful to the plant breeder, the agronomist and the grower. It would meet the paramount need of giving the plant breeder a comprehensive list of the various combinations of characters that are already in existence. It would help the agronomist and the grower to identify the variety and to select varieties suitable for their tract.

In Europe and America, in the case of the more important crops, the varieties already in cultivation have been registered as standard varieties, and new varieties are not registered unless they are distinctly different from the existing varieties in one or more recognizable characters and unless they are superior to them in some characters or qualities. The object of such a procedure is to ensure that no variety is foisted on the farmer before it has been thoroughly tested and to eliminate any possibility of old varieties being pushed into the market under new names. The registration of improved varieties also results in a consolidated and strictly comparable account of the new and valuable genetic stocks. Such registration therefore helps the plant breeder to know the important material that is available and which might be useful to him and at the same time it would help him to obtain such material for investigations.

In view of these considerations the Indian Council of Agricultural Research decided to encourage the registration of crop varieties in India. To begin with the choice fell on wheat. The Standing Wheat Committee of the Indian Council of Agricultural Research unanimously decided at its first meeting in 1936 that a register should be maintained at the Imperial (now Indian) Agricultural Research Institute, New Delhi, of (1) wheat varieties distributed for cultivation and (2) wheat strains grown on a small scale but which were of scientific interest. It was suggested that before this work was taken up, the methods and principles for the description of wheat varieties should be standardized. A special sub-committee, which may conveniently be referred to as the Wheat Nomenclature Committee, was appointed for this purpose. It met in Simla in June, 1940, and presented a standard schedule for the description of the various characters of this crop plant. This schedule, together with detailed recommendations and illustrations for the guidance of workers who might take up the description of wheat varieties, was subsequently published [Pal *et al.*, 1941].

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Material and method

The general plan followed for wheat registration is to record the detailed description of each variety and the evidence of its superior qualities. When it is desired to bring a new variety to the list of registration, it would be grown and tested to see if it was distinguishable from the existing varieties. Such a variety submitted for registration would be accompanied by a complete botanical description, its claim to superiority and a sample of seed.

The work on wheat registration referred to in this paper was started with 24 varieties evolved at the Indian Agricultural Research Institute : for the purposes of this study they were grown for three years in succession in the Division of Botany and the different characters were recorded in accordance with the recommendations of the Wheat Nomenclature Committee. A list of the varieties together with their register number is given in Table I.

Table I

Showing varieties registered, their registered number and origin

Registration number	Name of variety	Origin of variety
1	New Pusa 4	Selection from indigenous wheats
2	New Pusa 6	do.
3	New Pusa 12	do.
4	New Pusa 12-2	Selection from New Pusa 12
5	New Pusa 52	From the cross Punjab 9 × New Pusa 6
6	New Pusa 54	do.
7	New Pusa 80-5	From the cross New Pusa 4 × New Pusa 6
8	New Pusa 90	do.
9	New Pusa 100	From the cross Muzaffarnagar × Pusa 22
10	New Pusa 101	do.
11	New Pusa 111	Mutation from New Pusa 4
12	New Pusa 112	Reselection from New Pusa 4
13	New Pusa 113	Selection from natural cross in New Pusa 4
14	New Pusa 114	Selection from natural cross in Federation
15	New Pusa 120	From the cross New Pusa 52 × Federation
16	New Pusa 121	do.
17	New Pusa 122	do.
18	New Pusa 123	do.
19	New Pusa 124	do.
20	New Pusa 125	do.
21	New Pusa 126	do.
22	New Pusa 163-3	From the cross New Pusa 4 × Federation
23	New Pusa 163-4	do.
24	New Pusa 165	do.

Description of the characters

The descriptive data have been presented in a consolidated form following closely the specimen schedules published by the Wheat Nomenclature Committee in Tables III and IV. Other information is given in Table II.

Table II

1 Experiment Station	Indian Agricultural Research Institute, New Delhi	
2 Nature of soil	Mainly sandy loam—	
3 Average rainfall*	(a) For the whole year	19·83 in.
	(b) For the wheat season (October to March)	3·26 in.
4 Temperature range	(i) Maximum—	
	(a) For the whole year	89·17°F.
	(b) For the wheat season	80·55°F.
	(ii) Minimum—	
	(a) For the whole year	64·40°F.
	(b) For the wheat season	51·09°F.
5 Humidity range	(i) Maximum—	
	(a) For the whole year	100 per cent
	(b) For the wheat season	10 ,,
	(ii) Minimum—	
	(a) For the whole year	10 ,,
	(b) For the wheat season	16·75 ,,
	(iii) Mean—	
	(a) For the whole year	58·04 ,,
	(b) For the wheat season	59·02 ,,
6 Nature and amount of manure applied	Farm yard manure at the rate of 4,500 to 6,000 lb. per acre.	
7 Date of sowing	Last week of October to first week of November	
8 Seed rate	1 maund (82 lb.) per acre	
9 Average spacing	Drilling the seeds behind the plough, with lines one foot apart.	
10 Number of irrigations, with intervals	Three irrigations with intervals of 4 to 6 weeks	
11 Lay out: Randomised blocks		

Among the vegetative characters described, the hairiness of the leaf blade and of the leaf sheath requires special explanation as this character was not considered in detail by the Wheat Nomenclature Committee. The pubescence of the surface and of the margin are described separately in these two cases. During the course of these observations it has been found that there is some variation in the distribution of the hairs particularly on the surface, depending on the position of the leaf on

* For items 3, 4 and 5 the figures given for the wheat season are averages of five years while those given for the whole year are averages of only four years.

the plant and its age. To eliminate this difficulty, observations were made on plants four to six weeks old : the middle portion of the leaf from the third or the fourth node and the corresponding leaf sheath were studied in each case. In the case of the leaf blade, the pubescence of only the upper surface was observed. Based on their length as estimated by eye-judgment, three kinds of hairs are distinguishable : (1) 'very short' where the hairs are so short that to the naked eye they look very much like papillæ but are clearly visible under a pocket lens ; (2) 'short' and (3) 'long' where the hairs are clearly visible even to the naked eye and differ in length relatively to each other. In regard to the frequency of their distribution, 'sparse' and 'dense' are the two grades recognized.

Since the publication of the standard schedule for description of wheat varieties by the Wheat Nomenclature Committee, it has been found desirable to include for description some characters not mentioned therein. The characters newly introduced for description are :

1. *Colour of the leaf attachment*. This may be purple or colourless. Where purple, the colour may be in stripes or patches : other kinds of distribution of the pigment may be described wherever they occur.

2. *Colour of the leaf sheath*	These may be purple or green. Where purple, different grades can be distinguished.
3. *Pigmentation just below the culm node*	
4. *Colour of the coleoptile*	

5. *Colour of the ligule*. The ligule may be colourless or purple ; in the latter case different grades can be recognized. In some ligules the top margin alone may be purple-coloured.

6. *Shape of the ligule*. The margin may be truncated or conical.

7. *Size of the auricle*. (*a*) Long or short ; (*b*) Broad or narrow.

8. *Pubescence of the culm node*. This may be glabrous or hairy. Where hairy, the hairs may be sparse or dense in distribution. In plants where the distribution of hairs is very sparse, many of the nodes particularly the upper ones may even be glabrous. For this character the third or fourth node from the base has been taken for observation.

Although only two grades are recommended by the Wheat Nomenclature Committee, intermediate grades have been recognized, for the sake of convenience in the case of the following characters :

1. *Glaucousness of the plant*. Plants which are glaucous but not strikingly so, are classed as intermediate.

2. *Straw thickness*. The straw has been classed as thick, medium or thin.

The column 'presence or absence of the ligule' has been deleted from the schedule as it is self-evident that the ligule is present in all cases where the colour and shape are described.

The degree of attack by the three rusts, namely, yellow, brown, and black has been noted in the field on mature plants ; no attempt has been made to identify

TABLE III

Ear and grain characters

	Ear characters						Awn characters						Glume characters									Grain characters									
Old* number	New number	Shape of the ear	Length of the ear	Density of the ear	Number of spikelets	Position of the ear at maturity	Presence or absence of awns and degree of awning	Awn colour	Arrangement of the awns	Character of the awns: Tenacity	Character of the awns: Coarse or slender	Character of the awns: Brittle or tough	Glume hairiness	Glume colour	Glume size: Glume length	Glume size: Glume width	Glume shoulder shape	Beak size: Beak length	Beak size: Beak width	Beak shape	Tenacity of the glumes	Grain colour	Grain length	Grain texture	Grain shape	Crease width	Crease depth	Cheek shape	Bushel weight	1000-kernel weight (gm.)	Protein content
	N.P. 4	Fusiform	9·69	56·95	17·2	Erect	Awnless	..	..	..	..	..	Sparsely pubescent	Grade 2	Midlong	Midwide	Rounded	Short	Midwide	Obtuse	Persistent	Amber	Midlong	Hard	Ovate	Narrow	Shallow	Rounded	62·35	34·98	9·69
	N.P. 6	Fusiform	10·48	49·45	21·5	Erect	Long tipped	..	..	..	..	..	Glabrous	Grade 6	Midlong	Midwide	Rounded to square	Very short	Midwide	Obtuse	Persistent	Amber	Midlong	Semi-hard	Ovate	Wide and narrow.	Deep and Shallow	Angular and Rounded	61·00	32·44	13·81
	N.P. 12	Fusiform	11·86	60·35	19·5	Inclined	Awnless	..	..	..	..	..	Glabrous	Grade 5	Long	Midwide	Oblique to rounded	Very short	Midwide	Acute	Persistent	White	Midlong	Soft to semi-hard	Ovate	Narrow	Shallow	Rounded	57·58	32·00	9·06
	N.P. 12-2	Fusiform	12·29	63·25	19·2	Erect	Awnless	..	..	..	..	..	Glabrous	Grade 5	Midlong	Midwide	Rounded	Very short	Midwide	Acute	Persistent	Amber	Midlong	Hard	Ovate	Narrow	Shallow	Rounded	61·00	39·61	12·36
	N.P. 52	Oblong	9·54	42·20	21·8	Erect	Fully bearded	White	Adpressed	Persistent	Coarse	Brittle	Glabrous	Grade 1	Midlong	Midwide	Oblique to rounded	Very long	Narrow	Acuminate	Persistent	Amber	Midlong	Hard	Ovate	Narrow	Shallow	Rounded	64·78	34·80	9·70
	N.P. 54	Fusiform(oblong)	9·20	43·70	21·0	Erect	Fully bearded	White	Adpressed	Persistent	Coarse	Brittle	Glabrous	Grade 1	Midlong	Midwide	Oblique to rounded	Very long	Narrow	Acuminate	Persistent	Amber	Midlong	Hard	Ovate	Narrow	Shallow	Rounded	63·00	35·94	11·32
	N.P. 80-5	Fusiform (clubbed)	9·60	48·45	19·7	Inclined	Short tipped	..	..	..	..	..	Glabrous	Grade 2	Midlong	Midwide	Oblique to rounded	Very short	Wide	Obtuse	Persistent	Amber	Midlong	Hard	Ovate	Narrow	Shallow	Rounded	64·53	37·56	8·69
	N.P. 90	Fusiform (clubbed)	10·42	44·70	22·8	Erect	Long tipped	..	..	..	..	..	[illegible]	Grade 2	Midlong	Midwide	Rounded to square	Very short	Wide	Obtuse	Persistent	Amber	Midlong	Hard	Ovate	Wide	Shallow	Angular	63·80	35·47	9·94
	N.P. 100	Fusiform	9·68	47·75	19·5	Inclined	Fully bearded	White	Adpressed	Persistent	Coarse	Brittle	Glabrous	Grade 2	Midlong	Midwide	Oblique to elevated	Very long	Midwide	Acuminate	Persistent	Amber	Midlong	Semi-hard to hard	Ovate	Narrow	Shallow	Rounded	58·65	27·67	7·31
	N.P. 101	Fusiform	7·79	39·05	19·2	Inclined	Fully bearded	White	Adpressed	Persistent	Coarse	Brittle	Glabrous	Grade 3	Midlong	Midwide	Oblique	Very long	Midwide	Acuminate	Persistent	Amber	Midlong	Hard	Ovate	Narrow	Shallow	Rounded	62·43	29·74	8·04
	N.P. 111	Fusiform	10·96	62·65	17·5	Erect	Short tipped	..	..	..	..	..	Glabrous	Grade 2	Midlong	Midwide	Rounded to square	Very short	Wide	Obtuse	Persistent	Amber	Midlong	Hard	Ovate	Narrow	Shallow	Rounded	63·60	36·86	11·19
	N.P. 112	Fusiform	11·09	62·00	18·1	Inclined	Short tipped	..	..	..	..	..	Sparsely pubescent	Grade 2	Midlong	Midwide	Oblique to rounded	Very short	Wide	Obtuse	Persistent	Amber	Midlong	Hard	Ovate	Narrow	Shallow	Rounded	64·35	..	8·8
	N.P. 113	Fusiform	9·95	50·80	19·2	Inclined	Long tipped	..	..	..	..	..	[illegible] pubescent	Grade 2	Midlong	Midwide	Oblique to rounded	Short	Wide	Obtuse	Persistent	Amber	Midlong	Hard	Ovate	Wide	Deep	Angular	62·50	39·27	11·22
	N.P. 114	Fusiform	9·51	45·05	20·1	Erect	Fully bearded	Black	Adpressed	Persistent	Coarse	Brittle	Sparsely pubescent	Grade 7	Midlong to short	Wide	Oblique to rounded	Very long	Midwide	Acuminate	Persistent	Amber	Midlong to short	Hard	Oval	Wide	Deep	Angular	62·15	34·34	9·50
	N.P. 120	Fusiform	9·78	47·20	19·9	Erect	Fully bearded	Red	Adpressed	Persistent	Coarse	Brittle	Glabrous	Grade 4	Midlong to short	Wide	Rounded to square	Very long	Midwide	Acuminate	Persistent	Amber	Midlong to short	Hard	Ovate	Narrow	Shallow	Rounded	64·48	38·80	12·53
	N.P. 121	Fusiform	9·96	47·50	19·4	Erect	Fully bearded	Red	Adpressed	Persistent	Coarse	Brittle	Glabrous	Grade 4	Midlong	Midwide	Oblique to rounded	Very long	Narrow	Acuminate	Persistent	Amber	Midlong	Semi-hard to hard	Ovate	Wide and narrow.	Deep and shallow	Angular and rounded	60·73	39·38	9·15
	N.P. 122	Fusiform	8·43	45·40	17·8	Erect	Fully bearded	Red	Adpressed	Persistent	Coarse	Brittle	Glabrous	Grade 5	Midlong	Midwide	Wanting to oblique	Very long	Narrow	Acuminate	Presistent	Amber	Midlong	Semi-hard	Ovate	Wide and Narrow.	Deep and shallow	Angular and rounded	62·95	39·35	8·41
	N.P. 123	Fusiform	8·43	37·00	21·5	Erect	Fully bearded	White	Adpressed	Persistent	Coarse	Brittle	Glabrous	Grade 1	Midlong	Midwide	Oblique to rounded	Very long	Narrow	Acuminate	Persistent	White	Midlong	Hard	Ovate	Wide	Deep pitted	Angular	57·88	33·86	8·76
	N.P. 124	Fusiform (clubbed)	8·99	41·95	22·3	Erect	Fully bearded	White	Adpressed	Persistent	Coarse	Brittle	Glabrous	Grade 2	Midlong	Midwide	Oblique to rounded	Very long	Narrow	Acuminate	Persistent	Amber	Midlong	Hard	Ovate	Wide	Deep pitted	Angular	51·10	24·60	8·13
	N.P. 125	Clavate	9·10	42·10	20·6	Erect	Fully bearded	Red	Adpressed	Persistent	Coarse	Brittle	Glabrous	Grade 5	Midlong	Midwide	Wanting to oblique	Very long	Narrow	Acuminate	Persistent	Amber	Midlong	Hard	Ovate	Wide and narrow.	Deep and shallow	Angular and rounded	60·73	35·36	9·06
	N.P. 126	Fusiform (clubbed)	8·49	41·85	20·2	Erect	Fully bearded	Red	Spreading	Persistent	Coarse	Brittle	Glabrous	Grade 5	Midlong	Midwide	Oblique to rounded	Very long	Narrow	Acuminate	Persistent	Amber	Midlong	Semi-hard	Ovate	Wide	Deep	Angular	63·05	35·65	9·65
	N.P. 163-3	Fusiform	8·11	48·80	15·9	Erect	Awnless	..	..	..	..	..	Glabrous	Grade 6	Midlong	Wide	Rounded to square	Very short	Wide	Obtuse	Persistent	Amber	Midlong	Hard	Ovate-Oval	Narrow	Shallow	Rounded	60·75	43·00	10·46
	N.P. 163-4	Fusiform	8·46	50·85	16·4	Inclined	Awnless	..	..	..	..	..	Glabrous	Grade 6	Midlong	Wide	Rounded to square	Very short	Wide	Obtuse	Persistent	White	Midlong	Soft	Ovate-Oval	Narrow	Shallow	Rounded	61·33	43·52	10·53
	N.P. 165	Fusiform	11·66	63·75	17·8	Inclined	Awnless	..	..	..	..	..	Glabrous	Grade 2	Midlong	Midwide	Rounded to square	Very short	Wide	Obtuse	Persistent	Amber	Midlong	Hard	Ovate	Narrow	Shallow	Rounded	64·15	44·6	12·46

* The N. P. wheats were formerly known as I. P. (Internal Pusa) and P (Pusa) wheats. The varietal numbers, however, have not been changed at any stage. In the case of N. P. 4, for instance the corresponding old numbers are I. P. 4 and P. 4. The same is true of the old numbers of the other N. P. wheats reported in this articles.

D

TABLE IV

Vegetative and other character

Old number	New number	Early growth habit	Hairiness of: Leaf blade	Hairiness of: Leaf blade margin	Hairiness of: Leaf sheath	Hairiness of: Leaf sheath margin	Hairiness of: Auricle	Hairiness of: Culm node	Colour of: Coleoptile	Colour of: Young shoot	Colour of: Leaf attachment	Colour of: Leaf sheath	Colour of: Ligule	Colour of: Auricle	Colour of: Anther	Colour of: Stem	Pigmentation below the culm node	Shape of the ligule	Size of the auricle: Length	Size of the auricle: Breadth	Plant glaucousness	Straw thickness	Solidity of the straw	Degree of attack by: Yellow rust	Degree of attack by: Orange rust	Degree of attack by: Black rust	Resistant or susceptible to: Loose smut	Resistant or susceptible to: Flag smut	Maturity (Number of days from sowing to heading)	Plant height in cm.	Number of tillers per plant	Yield per plant in gm.
	N.P. 4	Erect	Hairs of unequal length. Both short in size. Shorter hairs dense and longer hairs sparse in distribution.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Sparsely pubescent	Green	Green	Purple striped	Purple striped	Colourless	Purple patched	Yellow	Green	Green	Truncate	Long	Narrow	Non-glaucous	Thin	Hollow	Traces	Medium	Traces	Susceptible	Highly resistant	95·0	116·7	12·6	15·05
..	N.P. 6	Intermediate	Hairs of equal length. Short in size. Distribution sparse.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Glabrous	Green	Green	Purple patched	Purple striped	Colourless	Colourless	Yellow	Green	Purple	Truncate	Long	Narrow	Non-glaucous	Medium	Hollow	Traces	Traces	Traces	Susceptible	Susceptible	97·3	119·6	11·7	12·6
	N.P. 12	Intermediate	Hairs of equal length. Short in size. Distribution sparse.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Glabrous	Green	Green	Purple striped	Purple striped	Colourless	Purple patched	Yellow	Green	Green	Truncate	Long	Narrow	Non-glaucous	Medium	Hollow	Traces	Medium	Medium	Susceptible	Moderately Resistant.	104·3	120·0	12·4	16·15
..	N.P. 12-2	Intermediate	Hairs of equal length. Short in size. Distribution sparse.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Glabrous	Green	Green	Colourless	Purple striped	Colourless	Colourless	Yellow	Green	Green	Truncate	Long	Narrow	Non-glaucous	Medium	Hollow	Traces	Medium	Medium	Not tested	Not tested	106·6	124·9	11·7	15·80
..	N.P. 52	Intermediate	Hairs of equal length. Short in size. Distribution sparse.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Densely pubescent	Green	Green	Purple striped	Purple striped	Colourless	Purple patched	Yellow	Green	Purple in a few plants. Mostly green.	Truncate	Long	Narrow	Intermediate	Medium	Hollow	Medium	Traces	Traces	Susceptible	Susceptible	103·3	116·9	12·8	18·45
..	N.P. 54	Intermediate	Hairs of equal length. Short in size. Distribution sparse.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Densely pubescent	Green	Green	Purple striped	Purple striped	Colourless	Purple patched	Yellow	Green	Green	Truncate	Long	Narrow	Non-glaucous	Thick	Hollow	Medium	Traces	Traces	Not tested	Not tested	102·0	116·4	9·6	14·25
..	N.P. 80-5	Intermediate	Hairs of unequal length. Both short in size. Shorter hairs; dense and longer hairs; sparse in distribution.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Sparsely pubescent or glabrous	Green	Green	Purple striped	Purple striped	Colourless	Purple patched	Yellow	Green	Green	Truncate	Long	Broad	Non-glaucous	Medium	Hollow	Traces	Medium	Traces	Susceptible	Resistant	99·6	121·4	17·9	20·6
..	N.P. 90	Intermediate	Hairs of equal length. Short in size. Distribution sparse.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Sparsely pubescent	Green	Green	Purple patched	Purple striped	Colourless	Purple patched	Yellow	Green	Green	Truncate	Long	Broad	Non-glaucous	Thin	Hollow	Medium	Traces	Traces	Susceptible	Susceptible	102·0	124·2	9·0	12·65
..	N.P. 100	Intermediate	Hairs of equal length. Short in size. Distribution sparse.	Hairs present only at the base.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Sparsely pubescent	Green	Green	Colourless	Purple striped	Colourless	Purple patched	Yellow	Green	Green	Truncate	Long	Narrow	Non-glaucous	Medium	Hollow	Medium	Traces	Medium	Susceptible	Moderately resistant.	113·0	121·7	10·1	12·3
..	N.P. 101	Intermediate	Hairs of equal length. Short in size. Distribution sparse.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal; length; very short. Distribution sparse.	Glabrous	Hairy	Sparsely pubescent or glabrous.	Green	Green	Purple patched	Purple striped	Colourless	Purple patched	Yellow	Green	Green	Truncate	Short	Narrow	Non-glaucous	Medium	Hollow	Medium	Traces	Traces	Susceptible	Susceptible	102·0	115·4	10·7	10·1
..	N.P. 111	Erect	Hairs of equal length. Short in size. Distribution sparse.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Sparsely pubescent or glabrous.	Green	Green	Purple striped	Purple striped	Colourless	Purple patched	Yellow	Green	Green	Truncate	Long	Broad	Non-glaucous	Medium	Hollow	Traces	Heavy	Traces	Susceptible	Highly resistant	96·3	118·8	14·6	20·77
..	N.P. 112	Erect	Hairs of equal length. Short in size. Distribution sparse.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal length; very short. Distribution dense.	Glabrous	Hairy	Densely pubescent	Green	Green	Purple striped	Purple striped	Colourless	Purple patched	Yellow	Green	Green	Truncate	Long	Narrow	Non-glaucous	Medium	Hollow	Traces	Medium	Medium	Not tested	Not tested	95·0	118·1	10·9	13·65
..	N.P. 113	Erect	Hairs of equal length. Short in size. Distribution sparse.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Sparsely pubescent or glabrous.	Green	Green	Colourless	Purple striped	Colourless	Colourless	Yellow	Green	Green	Truncate	Long	Narrow	Non-glaucous	Medium	Hollow	Traces	Medium	Traces	Not tested	Not tested	98·6	120·7	9·6	10·77
..	N.P. 114	Intermediate	Hairs of equal length. Short in size. Distribution sparse.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Densely pubescent	Green	Green	Purple patched	Purple striped	Purple margin	Purple patched	Yellow	Green	Green	Truncate	Long	Narrow	Non-glaucous	Medium	Hollow	Traces	Traces	Traces	Highly resistant	Susceptible	126·3	122·8	14·5	13·20
..	N.P. 120	Intermediate	Hairs of unequal length. Both short in size. Shorter hair; dense and longer hairs sparse in distribution.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Sparsely pubescent	Green	Green	Purple striped	Purple striped	Colourless	Colourless	Yellow	Green	Green	Truncate	Long	Narrow	Intermediate	Medium	Hollow	Traces	Traces	Traces	Highly resistant	Susceptible	113·6	124·5	11·9	14·50
..	N.P. 121	Intermediate	Hairs of equal length. Short in size, distribution sparse.	Hairs present up to about one third of thelength of the leaf from thebase.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Densely pubescent	Green	Green	Purple striped	Purple striped	Colourless	Colourless	Yellow	Green	Green	Truncate	Long	Broad	Intermediate	Thick	Hollow	Traces	Traces	Traces	Highly resistant	Susceptible	116·0	117·4	10·8	17·45
..	N.P. 122	Intermediate	Hairs of equal length. Short in size, distribution sparse.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Densely pubescent	Green	Green	Purple striped	Purple striped	Purple patched	Colourless	Yellow	Green	Green	Truncate	Long	Broad	Intermediate	Medium	Hollow	Heavy	Traces	Traces	Resistant	Susceptible	106·0	102·5	13·4	13·20
..	N.P. 123	Spreading	Hairs of equal length. Short in size, distribution sparse.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Densely pubescent	Green	Green	Purple striped	Purple striped	Purple patched	Colourless	Yellow	Green	Green	Truncate	Short	Broad	Intermediate	Thick	Hollow	Traces	Heavy	Traces	Susceptible	Susceptible	119·0	113·9	7·5	9·65
..	N.P. 124	Spreading	Hairs of equal length. Short in size, distribution sparse.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Densely pubescent	Green	Green	Purple striped	Purple striped	Colourless	Colourless	Yellow	Green	Green	Truncate	Long	Broad.	Intermediate	Medium	Hollow	Traces	Medium	Traces	Resistant	Susceptible	128·3	114·7	7·0	8·40
..	N. P. 125	Intermediate	Hairs of equal length. Short in size, distribution sparse.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Densely pubescent	Green	Green	Purple striped	Purple striped	Colourless	Purple patched	Yellow	Green	Green	Truncate	Long	Broad	Non-glaucous	Thick	Hollow	Medium	Traces	Traces	Susceptible	Susceptible	110·0	113·9	14·2	19·30
..	N.P. 126	Intermediate	Hairs of equal length. Short in size, distribution sparse.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Densely pubescent	Green	Green	Purple striped	Purple striped	Colourless	Colourless	Yellow	Green	Green	Truncate	Long	Broad	Intermediate	Thick	Hollow	Traces	Traces	Traces	Susceptible	Susceptible	109·0	103·5	9·4	12·95
..	N. P. 163-3	Erect	Hairs of unequal length. Both short in size. Shorter hairs dense and longer hairs sparse in distribution.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Sparsely pubescent or glabrous.	Green	Green	Colourless	Purple striped	Colourless	Colourless	Yellow	Green	Green	Truncate	Long	Narrow	Intermediate	Medium	Hollow	Traces	Medium	Traces	Highly resistant	Moderately resistant.	91·6	100·7	9·8	9·35
..	N.P. 163-4	Intermediate	Hairs of equal length. Short in size. Distribution sparse.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Sparsely pbescent, mostly glabrous.	Green	Green	Colourless	Green	Colourless	Colourless	Yellow	Green	Green	Truncate	Short	Narrow	Non-glaucous	Thick	Hollow	Traces	Medium	Traces	Highly resistant	Moderately resistant.	92·6	92·1	9·9	9·00
..	N.P. 165	Intermediate	Hairs of equal length. Short in size. Distribution sparse.	Hairs present up to about one-third of the length of the leaf from the base.	Hairs of equal length; very short. Distribution sparse.	Glabrous	Hairy	Sparsely pubescent or glabrous	Green	Green	Purple striped	Purple striped	Colourless	Purple patched	Yellow	Green	Green	Truncate	Long	Broad	Intermediate	Medium	Hollow	Traces	Traces	Traces	Resistant	Moderately resistant.	99·6	120·8	13·2	15·55

the races of the different rusts. Four grades have been recognized for this character : (1) traces, where the attack is very mild ; (2) medium, (3) heavy and (4) very heavy.

In Table II numerical grades are given in respect of glume colour. The numbers refer to the grades 1 to 9 given in Plate XXVI of the publication on the variability of Indian wheats (*loc. cit.*).

Where the ears are long-tipped, short-tipped or awnless, the awn characters are not described for obvious reasons.

With regard to the shape of the ear, some clubbing of the spikelets only at the ear-tops was observed in a few varieties (*viz.*, New Pusa 80-5) where the shape was distinctly fusiform. This fact has been specified wherever necessary.

The yields of particular varieties naturally fluctuate from season to season. All the N. P. wheats under commercial distribution (N. P. 4, 12, 52, 80-5, 101, 111, 125, 165) are potentially very high yielders under suitable conditions of soil and climate.

A key for identifying the varieties is provided (Appendix I).

APPENDIX I

Key to the 'New' Pusa' wheats

- Spike awnless or with very short tips—
  - Glumes glabrous—
    - Glume colour grade 2—
      - Spike shape fusiform, tapering distinctly, inclined at maturity . . . N.P.165
      - Spike shape fusiform, tapering slightly, erect at maturity . . . N.P.111
      - Spike shape slightly clubbed . . . N.P.80—5
    - Glume colour grade 5—
      - Grain colour white . . . N.P.12
      - Grain colour amber . . . N.P.12—2
    - Glume colour grade 6—
      - Grain colour white . . . N.P.163-4
      - Grain colour amber . . . N.P.163-3
  - Glumes sparsely pubescent—
    - Ear length medium . . . N.P.4
    - Ear length long . . . N.P.112
- Spike long-tipped—
  - Glumes glabrous—
    - Glume colour grade 2 . . . N.P.90
    - Glume colour grade 6 . . . N.P.6
  - Glumes sparsely pubescent . . . N.P.113
- Spike fully-bearded—
  - Glumes glabrous—
    - Glume colour grade 1—
      - Grain colour white . . . N.P.123

E

Grain colour amber—	
Plant non-glaucous (straw thick)	N.P.54
Plant glaucous intermediate (straw medium)	N.P.52
Glume colour grade 2—	
Spike shape fusiform	N.P.100
Spike shape fusiform (slightly clubbed at top)	N.P.124
Glume colour grade 3	N.P.101
Glume colour grade 4—	
Glume-shoulder oblique to rounded, non-shattering	N.P.121
Glume-shoulder rounded to square, shattering	N.P.120
Glume colour grade 5—	
Spike shape fusiform	N.P.122
Spike shape fusiform (slightly clubbed at top)	N.P.126
Spike shape clavate	N.P.125
Glumes sparsely pubescent	N.P.114

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PRELIMINARY STUDIES ON pH FLUCTUATIONS IN RICE SOILS DURING THE GROWTH OF RICE PLANTS

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(With three text-figures)

THE study of the effect of the pH—the hydrogen ion concentration—of soils on plant growth has been receiving wide attention. Arrhenius [1926], Trenel [1927], Kappen [1929] are some of the workers who devoted their attention to the study of pH and cereals. The optimum ranges of pH as suggested by them are for wheat 6·6 to 7·4, barley 7·2 to 8·0, rye 5·0 to 7·0 and oats 4·9 to 5·6.

From the foregoing it is clear that pH affects the growth of cereals. The effect may be both direct and indirect. Directly, the metabolism of the plant may be modified and indirectly, the availability of inorganic chemicals like iron, nitrogen, and phosphoric acid may be modified. Hence, a study of the soil pH is likely to give valuable indication of what is essential for maximum fertility under any given climatic condition. It is also likely to give an indication as to the effect of chemical fertilizers on the soil as well as on the plant that is grown therein. Hence, a study of soil pH in paddy lands is likely to be of very great agricultural value.

Most higher plants can grow in soils with pH ranging from 5·0 to 7·0. Rice has a wider range than this and can tolerate a pH range of 4·0 to 9·0.

Table I from Bruce [1922] will clarify this point.

TABLE I†

pH of rice soil

Locality	pH range	Rainfall in inches	Yield in lb. per acre
Ceylon	6·5—8·2	35—150	1010
South India	7·8—8·7	13—45	2700
Burma	8·1—8·7	40—89	2000
Federated Malaya States	4·4—7·2	54—88	1800
Siam	Neutral	41—77	1475
Phillipines	7·5—7·8	55—69	1700
Japan	4·5—6·9	47—59	2600

Abstract from *Bulletin No.* 57 *Department of Agriculture, Ceylon*

From Table I it is seen that rice can grow in a *p*H range of 4·4 to 8·7. Small [1946] states that Rice is alkali tolerant with a general optimum about *p*H 7·9, so that for good crop yields this crop may be regarded as alkaliphilous. There are, however, many rice varieties which may differ in their *p*H requirements for healthy growth and maximum yield. Jack [1923] remarks that the peat acids kill the young roots of paddy plants.

It is perhaps due to the wide range of *p*H toleration and the ease of obtaining suitable varieties for different soil reactions that much valuable literature on the subject is lacking. Dastur and Kalyani [1934] worked on the *p*H of paddy soils in Bombay. They studied the effect of four manurial treatments, *viz*., (1) control ; (2) ammonium sulphate ; (3) sodium nitrate ; (4) ammonium sulphate and sodium nitrate. The manures were applied on equal nitrogen basis. No mention is made about any basal dressing. The *p*H was determined in a clear soil solution by the hydrogen electrode. The *p*H of the soil solution ranged from 5·92 to 7·16 at different periods of crop growth. The mean value for *p*H for the four treatments, irrespective of the period of sampling, is reported as given below :

Control	Ammonium sulphate	Sodium nitrate	Ammonium sulphate and sodium nitrate
6·62	6·57	6·72	6·60

The conclusions drawn by the authors are: (1) The *p*H values of the soil decrease upto the end of July (seedling stage) and then rise upto the end of August (tillering stage) and again fall in the first week of September, (pre-flowering stage). Later, there is a rise upto the middle of September and then smaller fluctuations follow for a week and then there is a fall after flowering has set in (2) The *p*H values of the soil manured with sodium nitrate stand always highest while that manured with ammonuim sulphate stand lowest and the mixed manure and control stand in between these two.

Kapp [1932] has done some work in pot culture conditions in Arkansas. Table II gives the data on soil *p*H. The *p*H was determined in soil solutions by the quinhydrone electrode at the time of booting (shot blade) stage of the plants.

Phosphorus was applied as mono-calcium phosphate, and potassium as potassium chloride. The general conclusion drawn is that the sodium nitrate pots show a slightly higher *p*H than the ammonium sulphate pots. This conclusion is based on a mean difference of ·06 of a *p*H unit. All the treated pots show a higher *p*H than the untreated or control.

The scope of the present investigation was to follow the course of changes of *p*H values at various stages of growth of the rice plant in the Maximum Potentialities Experiment recently started in October, 1947 at the Paddy Breeding Station, Coimbatore, to study the effects of varying doses of nitrogen, potash and phosphoric acid applied individually and in combination over a basal application of green manure (sunn hemp) at 2,000 lb. per acre.

TABLE II

*Data on soil p*H

Treatments	*p*H	N : K : P
Control	7·15	4 0 4
500 lb. N (ammonium sulphate)	7·32	4 0 4
do. (sodium nitrate)	7·35	do.
do. ammonium sulphate plus 200 lb. P	7·27	do.
do. sodium nitrate plus 200 lb. P.	7·40	do.
do. ammonium sulphate plus 400 lb. P	7·30	do.
do. sodium nitrate plus 400 lb. P	7·30	do.
do. ammonium sulphate puls 600 lb. P	7·32	do.
do. sodium nitrate plus 600 lb. P	7·32	do.
do. ammonium sulphate plus 800 lb. P	7·24	do.
do. sodium nitrate plus 800 lb. P	7·40	do.
do. ammonium sulphate plus 1,000 lb. P	7·38	do.
do. sodium nitrate plus 1,000 lb. P	7·44	do.
do. cotton seed meal	7·35	do.
do. cotton seed meal plus 400 lb. P	7·50	4 16 4
do. cotton seed meal plus 300 lb. $CaCO_3$	7·39	4 16 4

This experimental field was specially selected for this study since it included variants comprising practically all treatments that may be given to rice plant for obtaining its maximum performance, and it was considered that the information for *p*H determinations obtained from this field would be sufficiently large and varied for drawing definite conclusions. *p*H was determined at fortnightly intervals in a representative sample of slushy soil drawn from the root zones of the plants, as far as practicable, immediately after it was drawn. In a few cases when the soil became dry, the semi-dry soil was brought again to the slushy condition by the addition of the irrigation water, and not by distilled water, to conform to the natural conditions.

The *p*H was determined by the quinhydrone apparatus after standardization with suitable buffer solutions of known *p*H just before starting each batch of determinations.

The details of treatments as well as the date obtained are given in Table III.

TABLE III

Serial number	Dates / Treatments	6—9 October 1947 pH	15—17 October 1947 pH	3 November 1947 pH	18 November 1947 pH	3 December 1947 pH	6 January 1948 pH	21 January 1948 pH	4 February 1948 pH	18 February 1948 pH	4 March 1948 pH
1	Control(no manure)	7·35	8·30	7·20	7·00	7·29	7·00	7·05	7·68	7·35	7·61
2	Leaf alone	7·65	8·01	7·39	7·20	7·22	7·63	7·48	7·52	7·63	7·81
3	Leaf + 30 N.	7·73	7·74	7·15	7·50	7·29	7·69	7·68	7·81	7·52	7·73
4	Leaf + 60 N.	7·69	7·97	7·05	7·55	7·22	7·75	7·52	7·87	7·67	7·71
5	Leaf + 90 N.	7·52	8·00	7·39	7·65	7·28	7·73	7·58	7·84	7·71	7·85
6	Leaf + 120 N.	7·45	7·87	7·13	7·95	7·55	7·69	7·48	7·77	7·71	7·73
7	30 lb. P_2O_5	7·55	8·03	7·35	7·15	7·38	7·75	7·65	7·81	7·57	7·86
8	(Leaf + 30 P_2O_5)	7·31	7·93	7·26	7·93	7·36	7·57	7·65	7·81	7·61	8·03
9	(do.) + 30 N.	7·71	7·83	7·40	7·25	7·46	7·75	7·75	7·81	7·35	7·85
10	(do.) + 60 N.	7·49	8·41	7·88	7·36	7·42	7·76	7·45	7·74	7·61	7·77
11	(do.) + 90 N.	7·38	8·16	7·39	7·20	7·35	7·63	7·77	7·61	7·65	7·91
12	(do.) + 120 N.	7·32	8·17	7·81	7·35	7·46	7·69	7·62	7·68	7·35	7·97
13	60 lb. P_2O_5	7·31	7·73	7·72	7·26	7·42	7·69	7·95	7·38	7·52	7·85
14	Leaf + 60 P_2O_5	7·62	8·09	8·12	7·26	7·31	7·66	7·71	7·57	7·61	7·65
15	(Leaf + 60 P_2O_5) + 30 N.	7·61	8·38	7·68	7·16	7·20	7·73	7·58	7·35	7·71	7·85
16	(do.) + 60 N.	7·44	7·84	7·40	7·72	7·46	7·69	7·52	7·81	7·35	7·69
17	(do.) + 90 N.	7·32	7·63	7·55	7·16	7·58	7·73	7·48	7·48	7·35	7·77
18	(do.) + 120 N.	7·40	8·06	7·55	7·26	7·28	7·81	7·68	7·86	7·45	7·85
19	60 lb. of K_2O	7·76	8·08	7·55	7·46	6·50	7·33	7·55	7·20	7·20	7·48
20	(Leaf + 60 K_2O)	7·30	7·74	7·40	7·36	6·83	7·35	7·52	7·63	7·39	7·63
21	(do.) + 30 N.	7·53	8·06	7·45	7·62	7·10	7·63	7·70	7·85	7·45	7·71
22	(do.) + 60 N.	7·45	8·02	7·39	7·68	7·15	7·45	7·48	7·67	7·39	7·69
23	(do.) + 90 N.	7·59	8·12	7·48	7·95	7·03	7·75	7·75	7·67	7·71	7·91
24	(do.) + 120 N.	7·62	7·91	7·45	7·45	7·15	7·70	7·81	7·71	7·75	7·97
25	30 P_2O_5 + 60 K_2O	7·40	8·02	7·55	7·55	7·13	7·54	7·89	7·38	7·42	7·78
26	(Leaf + 30 P_2O_5) + 60 K_2O	7·45	7·66	7·65	7·62	7·30	7·73	7·71	8·81	7·45	7·69
27	(do.) + 30 N.	7·42	8·04	7·65	7·58	7·42	7·58	8·04	7·48	7·35	7·52
28	(do.) + 60 N.	7·28	8·07	7·50	7·50	7·15	7·45	8·20	7·64	7·45	7·65
29	(do.) + 90 N.	7·49	7·70	7·45	7·36	7·18	7·58	7·89	8·71	7·35	7·62
30	(do.) + 120 N.	7·65	7·99	7·80	7·40	7·30	7·63	8·11	7·85	7·61	7·69
31	(60 P_2O_5 + 60 K_2O)	7·38	7·80	7·76	7·45	7·35	7·39	8·84	7·62	7·63	7·65
32	(Leaf + 60 P_2O_5 + 60 K_2O)	7·35	8·30	7·65	7·46	7·22	7·35	8·83	7·71	7·24	7·81
33	(do.) + 30 N.	7·80	7·90	7·72	7·46	7·32	7·67	8·20	7·62	7·68	7·72
34	(do.) + 60 N.	7·57	8·08	7·45	7·45	7·30	7·73	8·54	7·61	7·35	7·87
35	(do.) + 90 N.	7·31	7·70	7·65	7·40	7·18	7·50	8·55	7·61	7·35	7·69
36	(do.) + 120 N.	7·35	8·11	7·79	7·38	7·15	7·98	8·21	7·61	7·61	7·87

Green leaf at 6,000 lb. per acre ; P_2O_5 as ordinary super : K_2O as sulphate of potash ; N as suiphate to of ammonia ; green leapes—sunnhem

From the data obtained the following conclusions are drawn :

(1) A general similarity in *p*H variations with time irrespective of treatments is seen ;

(2) All the treated plots show a slightly higher *p*H than the 'no manure' control ;

(3) The differences in *p*H between plots treated with organic and/or inorganic fertilizers are not pronounced ;

(4) On the contrary, the seasonal variations in reaction are well pronounced ;

(5) Two maxima and two minima in *p*H values are obtained during the growth period of the rice plant ; and

(6) The trend of the *p*H curves strongly indicates that it corresponds to definite growth functions of the rice plant. This is discussed in detail below.

Discussion

Two basic facts are brought out prominently by this study, viz. :

(*a*) There is a striking similarity in the *p*H curves when plotted against time irrespective of treatments (Fig. I).

(*b*) The variations in *p*H value with time are much greater than that obtained with even such drastic treamtents as incorporation of organic and/or inorganic manures in the soil medium. This would indicate that there must be a law governing the changes in reaction in the medium on which the rice plant grows. It is seen that it is not easily affected by additions to the medium of even strong salts or easily decomposable organic matter. On the contrary, the changes in reaction are greatly influenced by time factor. In other words, the growth of the rice plant causes the changes in the reaction of the medium on which it grows. Unfortunately there were no fallow plots with treatments from which comparisons could be made in regard to variations in *p*H in cropped and fallow soil. This would have brought home the thesis that the growth of the rice plant causes the changes in reaction of the medium on which it grows. However, work done elsewhere shows that the soil reaction in a cultivated fallow changes very little with time. Kelly [1923] has shown that Hagerstown Loam *p*H changes very little during one year's observation as revealed by the Table IV.

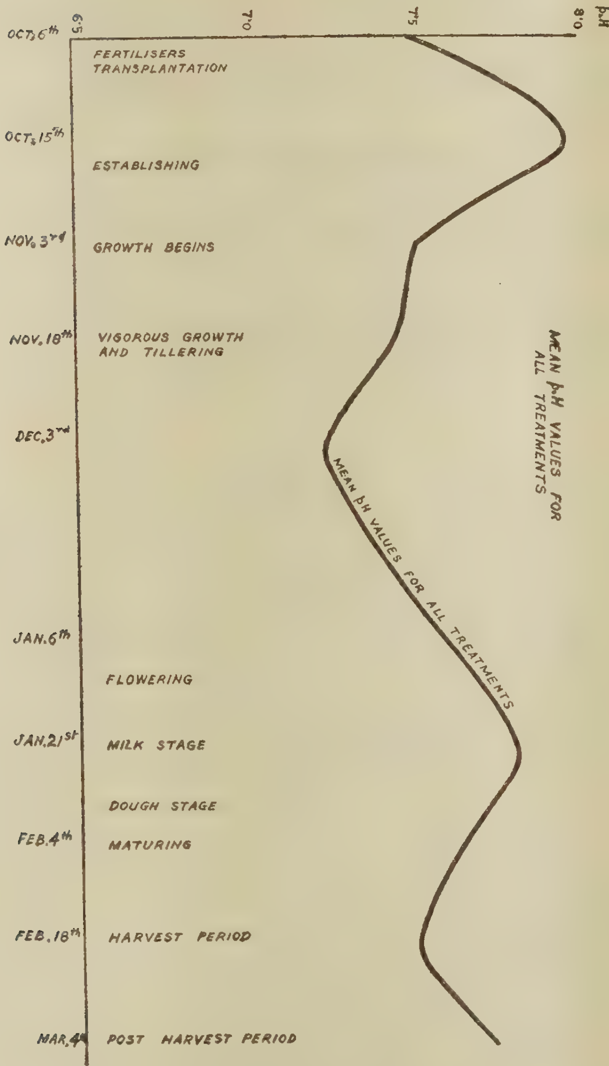

Fig. 1. Seasonal fluctuations in soil pH.

TABLE IV

*p*H *of Hagerstown loam*

Month	Surface	15 cm.
April	7·0	6·9
May	7·0	7·3
June	7·0	6·6
July	7·C	6·7
August	7·0	6·6
September	6·6	6·3
October	7·1	6·8
November	7·3	7·0
December	6·4	6·0'
January	7·0	..
February	6·8	6·8
March	7·0	6·8

On this analogy it may be presumed that gorwth of plant is the factor in causing variations in *p*H. A close examination of the last point step by step will reveal the truth of this statement.

Very soon (15 days) after green manure application and transplantation there is seen a steep rise in *p*H in all treatments including ' no manure ', reaching its first maximum.

This is the stage when ammonia production is carried on vigorously from the green manure and other nitrogenous manures added or the organic matter already present in the soil in the plots which did not receive any nitrogenous manure. Ammonia produced gets accumulated in the soil. In this short interval the plants have not yet got over the shock of transplantation and are therefore not yet in a position to rapidly utilize the ammonia. Hence, it is accumulated in the soil and causes an alkaline reaction and so the *p*H rises steeply.

Similar findings have been reported by (1) White [1918] who has found a great reduction in lime requirements of soils during the first two weeks after treatment with green manure which effect he attributes to the conversion of the nitrogenous material of the manures to ammonia ; (2) Willis and Rankin [1930] who have shown that organic forms of nitrogen become converted to ammonia very rapidly in a soil cropped with cotton seedlings ; and (3) by Clevenger and Willis [1935] who studying

the effect of ammonification of organic nitrogen in sand cultures have reported a rapid ammonification raising the pH sharply to a maximum of 8·0 and 8·5 in the first sixteen days.

The second stage in soil reaction occurs within about 30 days after transplantation. The plants are beginning to establish themselves and start absorbing the ammonia accumulated in the soil thereby causing a fall in pH. This continues for a period of two months during which time the plants start growing vigorously and tiller profusely and therefore they not only utilize practically all the accumulated ammonia, but also call for more.

There are various contributory factors in pH changes in soil, chief of which are the physiological activity of the plants and biological activity causing biochemical changes in the soil medium. The two are so closely inter-connected and inter-related that it is impossible to separate one from the other. Hence, the fall in pH is attributed to the vigorous assimilation of ammonia as well as the various other factors mentioned above.

The third stage is found between $3\frac{1}{2}$ to $4\frac{1}{2}$ months after transplantation. It is now an accepted fact that the rice plant takes up nitrogen in the form of ammonia during its earliar stages of growth but requires it in the form of ammonia and nitrate later on. When exactly the switch over takes place and whether it is abrupt or gradual are not definitely known. It is however, believed that it is gradual and begins some time before flowering stage and may continue for some time after it—*vide* Nagaoka [1904], Daikuhara [1905], Aso and Bahadur [1906], Krauss [1907], Kelly [1911, 1914], Trelease and Paulino [1920], Dastur and Malkani [1933], Dastur and Kalyani [1934]. Therefore, the ammonia which may continue to be produced—depending upon the availability of nitorgenous substances—at the time of the switch over may not at the same speed be nitrified and therefore becomes once again accumulated in the soil rendering it alkaline. The speed of ammonia production would necessarily be much lower than it would be at the start, since much of the nitrogenous matter would have already been used up by now and also the range of the soil reaction is at this stage more favourable for nitrification than ammonification—*vide* Kappen [1929] and Waksman [1932]. Further, the utilization of ammonia by the plant is also less than in the earlier stage. Hence, at the flowering period and for some time thereafter, the ammonia accumulation in the soil is neither very much nor sudden and correspondingly the pH rises slowly and gradually to a second maximum. This goes on till the maturity of grains.

The final stage in soil reaction is seen five months after transplantation. The plants are now ready for harvest. No more water is let into the fields and the soil becomes drier. Ammonification has now stopped either for want of material or insufficiency of moisture. No further disturbances due to crop growth are taking place as this too has practically come to an end. Hence, the reaction too becomes as it was at the start. The view expressed here is in perfect agreement with the findings of Huberty and Hass [1940], Baver [1927] and Kelly [1923] among others who have observed similar seasonal fluctuations in soil pH—the hydrogen ion concentration changing over to the original level at the end of the cropping season.

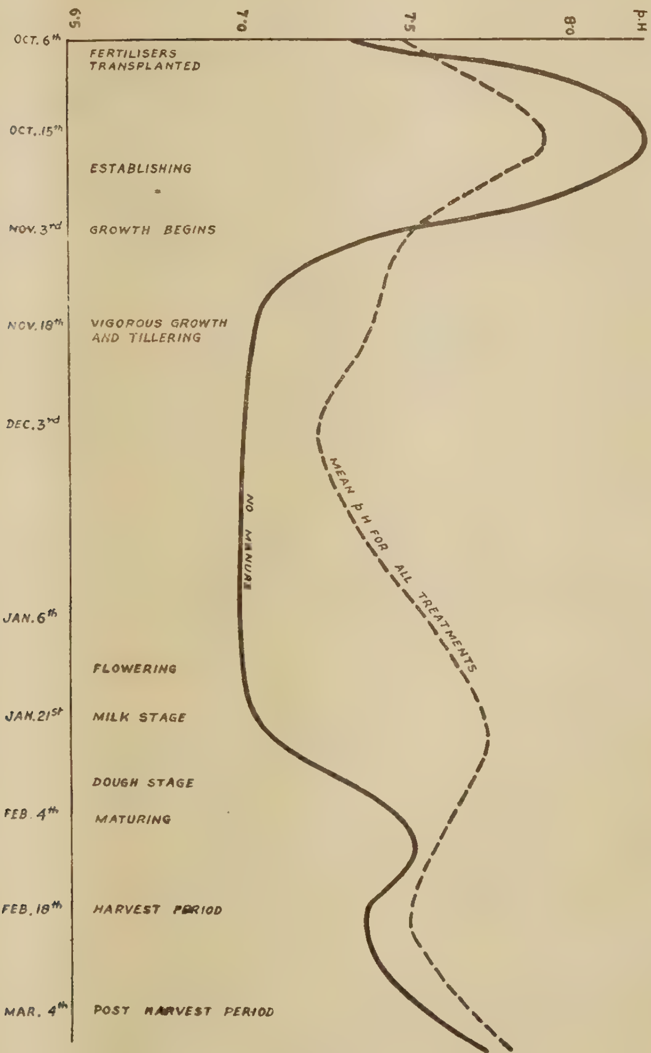

Fig. 2. Comparison of the trend of the two treatments

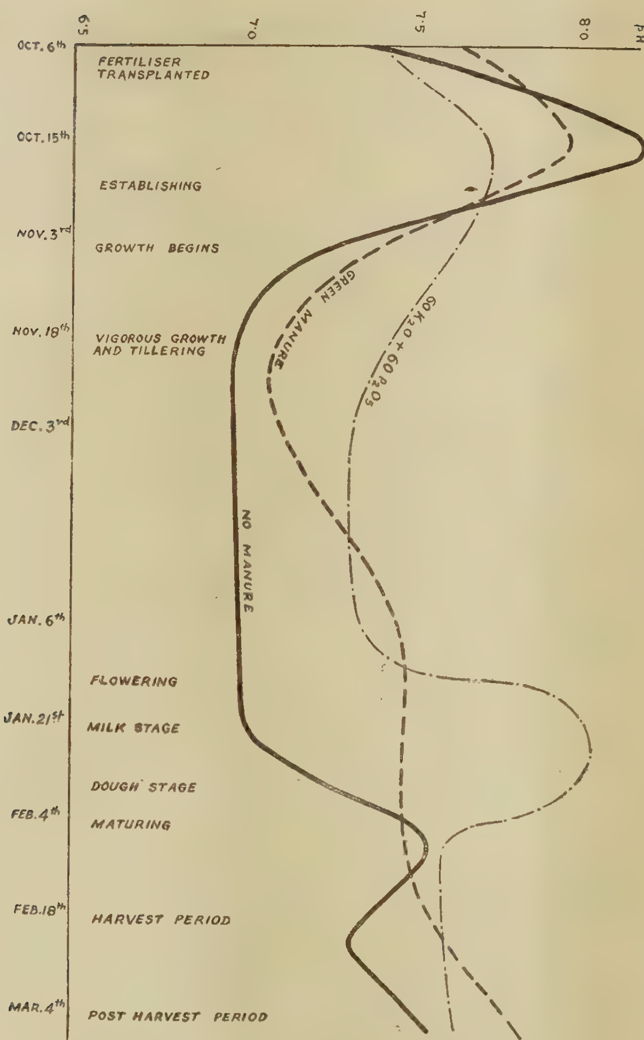

FIG. 3. Comparison of the trend of three treatments

The further rise in pH in the post-harvest period is probably due to desiccation and consequent salt accumulation of alkaline nature. All these have been depicted in Fig. 1. The curve is obtained by plotting the mean pH values for all treatments including that of ' no manure ' against time in the time column ; the various stages of the growth of the plant are also given.

Two curves are given in Fig. 2, one the mean pH values of all teratments (same as before) and the other, the values obtained in the ' no manure ' plot only. The trend of the two curves is similar in general but the flat nature of the curve for ' no manure ' during the vigorous growth period of the plant is well brought out.

In Fig. 3, the ' green manure curve ' is compared with the ' 60 K_20 plus 60 P_2O_5 curve ' and the ' no manure ' curve. The similarity in the general trend of the three curves are clearly brought out even when such divergent treatments are compared with one another. This leads one to conclude that the one important factor influencing the soil reaction is the crop growth.

As may be evident from the title, it embodies only the preliminary work. The study had to be started in a great hurry due to causes beyond the authors' control. It is proposed to continue it next rice season with the object of bridging the gaps found in this preliminary work.

SUMMARY

With the object of following the fluctuations in soil reaction during the crop growth of the paddy, pH determinations were made at fortnightly intervals in the plots under Maximum Potentialities Experiment conducted at the Paddy Breeding Station, Coimbatore.

The Experiment included 36 manurial treatments. The data regarding pH are found in Table I.

The general similarity in the variations of pH with time are well brought out by the curves (1), (2) and (3).

The conclusions drawn are ;

(1) The treated plots show a slightly higher pH than the no manure plot ;

(2) The differences in pH between the treated plots themselves are not pronounced ;

(3) The seasonal variations in reaction, on the other hand, are well pronounced ;

(4) Two maxima and two minima in pH values were obtained during the crop growth. The maxima being at start and at flowering—Milk stage ; and the minima during the vigorous growth and maturity periods ; and

(5) The trend of the pH curves strongly indicates that it corresponds to definite growth functions of the rice plant.

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NATURAL FLORA AS AN INDEX OF SOIL QUALITY* II

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(With Plates V and VI)

It has been shown previously that variations in the naturally growing flora in relation tothe more prominent soil features of those areas can be attributed to factors such as elevation, rainfall, genetic development of soil profile from parent rock, etc. [Taylor *et al*, 1934 ; Taylor *et al*, 1936 ; and Hoon, 1939]. Within narrower limits, however, some types of natural flora are known to flourish only under particular sets of soil conditions and are either entirely absent, or manifest poor growth at places where those soil conditions are lacking.

In a previous publication Hoon and Metha [1937] had described some distinctive soil features of areas colonised by a few such types of natural flora. In the course of further soil survey work some more types of flora were met with whose occurrence seemed to be associated more or less with certain soil factors of those areas. It was, therefore, considered of interest to extend the previous investigation to flora colonising areas with soil which might definitely be classed as inferior at that stage. An assessment of soil impoverishment in terms of the surface vegetation, if a few varieties of natural flora indicating the various stages of soil deterioration can be found, would undoubtedly furnish a better index than the present method of quality survey by *thur* and *sem girdawris*. Those *girdawris* involving, as they do, merely a visual observation of the soil surface features and classing an area as deteriorated only at a stage when the yield falls below 25 per cent of the normal, i.e. when 75 per cent of deterioration has already set in, naturally fail to detect soil deterioration at an early stage.

Types of natural flora

The following four of the most common types of natural flora, which colonise such areas as, when put under cultivation, afford poor crop yield form the basis of the present investigation :

(*a*) *Harmal* (*Peganum harmala*) : a glabrous, densely leafy, 1-3 ft. high herb with perennial roots and annual aerial stems and branches (Plate V, fig. 1) ;

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* For the first part of this series please see *Research Publication* III (3), (1937) of the Punjab Irrigation Research Institute entitled 'A study of the soil profiles of the Punjab plains with reference to their natural flora' by R. C. Hoon and M. L. Mehta.

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(*b*) *AK* (*Calotropis procera*) *:* an erect shrub 6-8 ft. high branching from or near the base ; young parts clothed in white cottony tomentum ; abundant in the sub-Himalayan tracts and adjacent plains or fallow land, waste ground, etc. In certain localities, it attains almost to a small tree with a stem of about four inches diameter at the base (Plate V, figs. 2(*a*) and (*b*)) ;

(*c*) *Sarkana* or *sarkanda* or *sar* or *munja* or *kana* (*Saccharum munja*) *:* perrennial tufted, stem 10-20 ft. in dry places, 6-7 ft. high ; glabrous below the panicle. Very common in low sandy places subject to inundation, springing up often in dense masses but dying out when overtopped by coppice shoots (Plate VI, fig. 3) ;

(*d*) *Lani* or *lana* (*Suaeda fruticosa*) *:* a much branched succulent glabrous shrub 2-4 ft. high, often gregareous and grows on saline soils ; flowers have a foeticide smell. An impure form of sodium carbonate (*sajji*) is made from the extract of the plant ash (Plate VI, fig. 4).

Collection of soil samples

It was considered of interest to examine the main soil characteristics of areas where the above types of flora were found to grow luxuriantly. As soil deterioration at its climax is indicated by land becoming completely devoid of vegetation, therefore besides studying the nature of soils from above areas, those from areas bearing no vegetation (Plate VI, fig. 5) were also included for investigation to elucidate, if possible, the stages leading to complete land deterioration.

For taking soil samples, a suitable spot of, say, 50 ft. × 50 ft. was selected at each site. A special form of pit with one clean-cut vertical side, exposing the profile up to a depth of about 48 inches was excavated. The soil sampling was done according to the various strata met with up to the excavated depth.

All the sampling sites are located in the canal irrigated region of the Punjab (now West Punjab) which may be classed as semi-arid region with a normal annual rainfall ranging between 10-14 inches during the year.

Laboratory testing of soil samples

The soil samples were analyzed for the following :

(*a*) Percentage content of *kankar* and gravel ;

(*b*) Mechanical analysis, i.e. percentage fraction of sand (particles 2·0—0·2 mm.), fine sand (0·2—0·02 mm.), silt (0·02—0·01 mm.), fine silt (0·01—0·002 mm.) and clay (particles below 0·002 mm.) ;

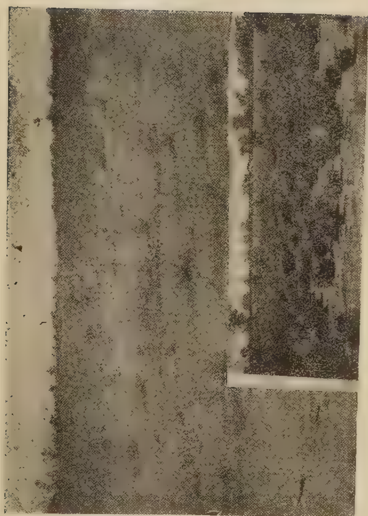

FIG. 1. A typical are under *harmal* (*Peganum harmala*)

FIG. 2(*a*). A typical area under *AK* (*calatropis procera*)

FIG. 2(*b*). A typical area under *AK* (*calatropis procera*)

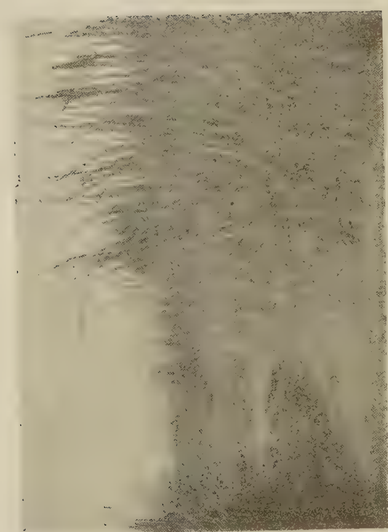

FIG. 3. A typical area under *sarkanda* (*Saccharum munja*)

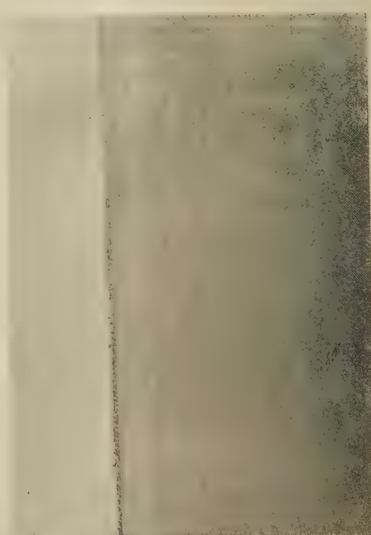

FIG. 4. A typical area under *lani* (*Suaeda fruticosa*)

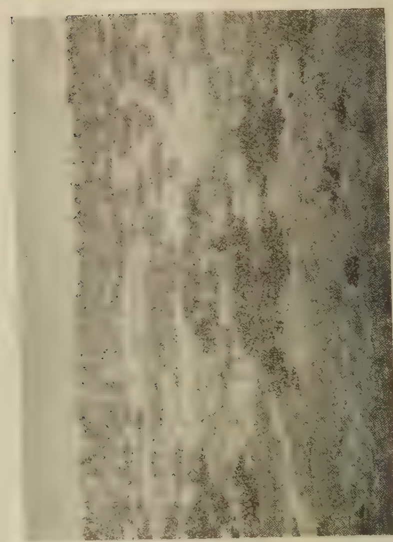

FIG. 5. A typical patch devoid of all vegetation

(*c*) Chemical analysis of water extracts of soils for the percentage contents of total soluble salts, chlorides and sulphates. In a few cases where nitrates were also indicated they were determined colorimetrically by phenol-disulphonic acid method ;

(*d*) *p*H of soil water suspension (1 : 5 soil-water ratio) determined by the glass electrode [Hoon, 1931] ;

(*e*) Dispersion co-efficient (D.C.), i.e. the ratio between the percentages of clay on autodisintegration (D.F.) to the total clay on complete dispersion [Puri, 1930]. The higher the value of D.C. the more impeded the movement of water through that soil would be ;

(*f*) Calcium carbonate content ;

(*g*) The contents of exchangeable sodium, potassium, calcium and magnesium expressed as milli-equivalents ;

(*h*) Degree of alkalisation. Puri [1934] has defined the degree of alkalisation (D.A.) of soils as the ratio of the exchangeable sodium and potassium (n) to the maximum amount of monovalent ions the soil is capable of binding by exhaustive treatment with a natural salt solution (N). He has shown that for soils with D.A. less than 25 per cent crop yields are not effected, between 25 per cent to 75 per cent there is inverse linear relationship between that characteristic and yield and beyond 75 per cent the crop yield is greatly diminished.

Hoon and Mehta (loc. cit.) have pointed out that in the case of alkaline soils where there is little hydrogen in the exchange complex the value $\frac{\text{Monovalent bases} \times 100}{\text{Total exchangeable bases}}$ would approximate to Puri's D.A. figures. The values of D. A. reported in the present paper have, therefore, the latter interpretation.

The results of analyses of the sets of soil samples representing each of the four types of flora and the areas devoid of vegetation are given in Tables I to V.

Discussion of the results of analyses of soils in relation to natural surface flora

A comparative statement of the main soil characteristics as revealed by the results of various analyses of soils representing different natural surface flora and from areas devoid of any vegetation is presented in Table VI and brings out their variations along the soil profiles representing various flora and other conditions.

Harmal has peculiar affinity to establish near abondoned brick kilns or old earth mounds. Although ordinarily the nitrate content of the Punjab soils is negligible, the soils under *harmal* have appreciable nitrate content as seen from Table I. The results of the chemical analysis of water extracts and *p*H of soils up to a depth of five feet from a typical *harmal* area where the top soil was being employed for the manufacture of nitre are given in Table VII.

TABLE I

Analytical results of soil profiles from area under harmal

Serial number	Location	Depth of horizons	Soil characteristics	Results of mechanical analysis: Percentage of sand	Percentage of fine sand	Percentage of silt	Percentage of fine silt	Percentage of clay	Percentage of calcium carbonate content	Chemical analysis of water extracts: Percentage of total solids	Percentage of chlorides as NaCl	Percentage of sulphates as Na_2SO_4	Percentage of nitrate as $NaNo_3$	pH	Dispersion coefficient	Exchangeable Base content in milli-equivalents: Na	K	Ca	Ng	Degree of alkalisation
1	Raipur District Sheikhupura	0 in.—10 in.	Brownish, fairly stiff	5·61	51·02	11·23	15·02	10·33	3·59	0·07	0·01	0·01	0·0046	8·72	18·87	0·29	1·15	10·80	1·40	10·63
		10 in.—40 in.	As above but less compact and contains *kankar* nodules	2·46	55·07	15·25	11·00	7·38	8·36	0·09	0·01	0·01	0·0223	8·47	18·96	0·12	0·39	9·30	0·90	4·67
		40 in.—72 in.	As above but contains less *kankar* nodules	0·53	51·68	17·05	14·75	5·83	9·73	0·10	0·01	0·01	0·0007	8·47	0·36	0·54	0·33	8·65	1·30	8·32
2	R. D. 368000 Burala branch extension area	0 in.—½ in. *i.e.* surface scrapping	Scaly soil surface layer	1·38	34·44	16·88	21·05	10·95	11·91	0·14	0·01	0·01	0·0036	8·29	29·21	traces	1·60	20·00	1·25	7·00
		½ in.—5 in.	Light brown, compact, containing roots throughout	1·11	52·25	13·13	11·05	7·53	12·35	0·06	traces	0·01	0·0006	8·57	48·15	do.	1·35	15·80	1·65	7·18
		5 in.—14 in.	As above and containing lime concretions	0·26	55·22	14·80	9·65	4·05	11·80	0·97	0·06	0·87	0·0014	7·98	28·40	0·33	traces	19·80	0·70	1·44
		14 in.—36 in.	Sandy, not compact as above	0·36	63·59	11·28	7·10	2·50	9·26	1·47	0·40	0·89	0·0062	8·02	66·02	0·31	do.	14·00	0·75	1·99
3	Vaniaka Vehnewala near R. D. 879000 Burala branch extension area	0 in.—½ in. *i.e.* surface scrapping	Scaly soil surface layer	2·72	41·94	14·18	19·35	8·28	4·88	0·18	0·01	0·02	0·0208	8·26	43·45	traces	1·90	14·30	1·00	11·05
		½ in.—15 in.	Brownish, compact	4·14	50·37	13·95	14·30	7·50	3·97	0·09	0·01	0·04	0·0046	8·39	39·00	do.	1·25	16·00	1·25	6·76
		15 in.—34 in.	As above but contains *kankar* nodules	2·81	51·93	15·30	14·15	6·35	5·35	0·11	0·02	0·05	0·0007	8·47	39·36	0·24	1·06	18·30	1·65	6·12
		34 in.—48 in.	More compact and contains more *kankar* than above	1·74	49·48	15·30	14·20	7·23	7·47	0·06	0·01	0·02	0·0003	8·51	31·81	traces	0·85	19·40	1·60	3·89
4	Near the third milestone on Lyallpur Satyana road	0 in.—5 in.	Brownish, loose and friable	1·00	47·88	18·10	14·40	9·75	0·59	0·07	traces	0·03	0·0005	8·26	30·25	traces	1·50	11·00	1·05	11·07
		5 in.—18 in.	More compact than above	5·06	41·94	15·70	18·03	13·60	1·73	0·09	0·01	0·05	0·0041	8·00	32·87	0·32	0·83	20·50	1·20	5·25
		18 in.—26 in.	Deep brown coloured and very compact	4·24	40·37	13·85	16·95	15·45	2·73	1·34	0·02	1·05	0·0019	7·32	9·06	traces	0·20	24·00	0·60	0·81
		26 in.—48 in.	As above but less compact	3·88	41·03	13·48	18·23	17·15	1·98	1·10	0·03	0·19	0·0022	7·44	7·73	do.	0·20	24·90	0·70	0·78
5	Area in Chak No. 209 near the 79th milestone on Lahore Lyallpur road	0 in.—11 in.	Chocolate brown coloured loose and friable	3·99	45·75	16·28	15·70	11·15	3·60	0·05	0·01	0·02	0·0004	8·34	30·50	0·68	0·21	19·90	1·20	3·64
		11 in.—22 in.	Very compact and contains *kankar* nodules	3·75	45·45	16·33	14·10	11·38	6·80	0·14	0·03	0·08	0·0008	7·85	38·23	0·24	0·51	22·80	0·90	3·07
		22 in.—48 in.	As above but with more *kankar* nodules	2·68	45·35	14·85	13·00	10·60	9·73	0·38	0·04	0·12	0·0095	7·76	23·78	0·73	0·57	15·20	1·40	7·26

TABLE II

Analytical results of soil profiles from areas under AK (Calatropis procera)

Serial number	Location	Depth of horizons	Soil characteristics	Results of mechanical analysis					Percentage of calcium carbonate content	Chemical analysis of water extracts			pH	Dispersion co-efficient	Exchangeable base content in milli-equivalents				Degree of alkalisation
				Percentage of sand	Percentage of fine sand	Percentage of silt	Percentage of fine silt as-NaCl	Percentage of clay		Percentage of total solids	Percentage of chlorides as NaCl	Percentage of sulphates as Na_2SO_4			Na	K	Ca	Mg	
1	Bhani Chadran R. D. 200000 of Kabra distributory Burala branch Extension area	0 in.—½ in.	Darkish brown coloured; structureless	3·89	43·41	19·10	14·53	10·43	2·82	0·15	0·01	0·01	8·19	27·94	0·73	1·97	3·90	1·20	21·10
		½ in.—18 in.	Greyish brown, compact	3·01	35·68	24·58	19·45	10·80	..	0·05	0·01	0·01	8·55	39·35	0·38	0·92	7·60	0·95	18·20
		18 in.—27½ in.	As above but more compact	9·13	43·79	20·20	14·60	8·25	0·725	0·04	0·01	0·01	8·45	43·40	0·32	0·98	6·00	0·95	15·75
		27½ in.—32½ in.	Hard band of fine-textured soil	8·02	29·48	17·60	24·50	16·00	0·23	0·06	0·01	0·01	8·24	36·25	0·21	0·19	7·55	0·85	4·55
		32½ in.—48 in.	Sandy	15·33	67·99	6·18	3·68	2·43	..	0·04	0·01	0·01	8·38	18·52	0·63	0·07	6·25	0·95	14·28
2	Shahjree near Kundian	0 in.—7 in.	Loose and coarse soil, contains roots	59·16	30·85	1·58	1·35	3·88	..	0·07	0·01	0·01	8·80	39·94	0·40	0·30	5·10	1·50	9·59
		7 in.—13 in.	As above but more compact due to finer sand	50·38	33·14	3·23	3·48	4·72	1·48	0·08	0·02	0·01	8·82	24·31	0·22	0·58	6·05	1·75	8·77
		13 in.—22 in.	Less compact than above	52·87	29·72	3·18	3·75	5·18	1·98	0·08	0·02	0·01	8·73	9·27	0·37	0·53	6·35	1·75	10·50
		22 in.—48 in.	Fairly loose soil	52·82	29·42	3·95	3·43	4·60	2·48	0·05	0·02	0·01	8·96	16·30	traces	1·00	6·75	1·75	10·53
3	Area near R. D. 329000 on Burala branch extension	0 in.—4 in.	Light brown, loose, structureless	6·74	55·74	11·18	9·78	7·50	6·72	0·05	0·01	0·01	8·49	64·66	0·42	0·78	19·70	0·90	5·50
		4 in.—8 in.	As above, but more compact due to finer sand	8·04	53·73	11·45	10·33	6·98	5·48	0·06	0·01	0·02	8·40	33·54	0·39	0·71	17·90	0·90	5·53
		8 in.—30 in.	Brownish, contain lime concretions	5·70	51·90	12·70	10·83	7·20	7·48	0·09	0·02	0·04	8·39	26·39	0·73	0·47	18·10	1·35	5·81
		30 in.—48 in.	More compact and containing more lime concretions	1·77	54·50	13·10	12·45	7·00	10·22	0·11	0·03	0·05	8·62	51·06	1·42	0·33	17·30	1·80	8·39
4	Chak 485 on Burala Extension area near R. D. 317000 Burala branch	0 in.—5 in.	Greyish brown compact	15·45	60·33	6·38	6·13	5·80	2·35	0·07	traces	0·02	8·60	37·93	0·28	0·81	11·70	1·10	7·92
		5 in.—24 in.	Brownish, less compact than above	11·26	47·41	8·68	12·43	10·50	5·47	0·07	0·01	0·02	8·42	42·39	0·46	0·39	19·00	1·50	3·98
		24 in.—48 in.	Light brownish; more compact than above, contains lime concretion	8·79	48·49	8·88	13·20	10·43	6·85	0·07	0·01	0·02	8·48	36·80	0·31	0·44	16·40	2·10	3·90

TABLE III

Analytical results of soil profiles from area under sarkanda (Saccharum munja)

Serial number.	Location	Depth of horizons	Soil characteristics	Results of mechanical analysis: Percentage of sand	Percentage of fine sand	Percentage of silt	Percentage of fine silt	Percentage of clay	Percentage of calcium carbonate content	Chemical analysis of water extracts: Percentage of total solids	Percentage of chlorides as NaCl	Percentage of sulphates as Na_2SO_4	pH	Dispersion co-efficient	Exchangeable base content in milli-equivalents: Na	K	Ca	Mg	Degree of alkalisation
1	Budo khaki Tehsil Shahdara, District Sheikhupura	0 in.— 2 in.	Light brownish ; loose	21·71	33·72	8·85	19·30	11·45	0·39	0·46	0·02	0·13	8·36	31·00	0·58	0·12	7·15	0·60	8·85
		2 in.— 6 in.	Somewhat darker coloured than above	18·16	48·53	5·15	12·25	8·10	0·24	0·07	0·01	0·01	8·39	39·57	0·13	0·42	4·90	0·90	8·66
		6 in.—36 in.	Sand	40·74	54·12	0·35	0·60	0·65	0·24	0·04	0·01	0·03	8·48	*nil*	0·24	0·31	2·70	0·95	13·10
2	Mohd. Janwala, village Chak Khanan, District Shahpur	0 in.— 8 in.	Brownish ; loam	10·26	36·93	10·88	22·50	12·98	..	0·05	0·01	0·01	8·77	37·74	0·55	0·40	10·30	0·95	7·79
		8 in.—18 in.	More compact than above	10·34	72·42	5·10	4·95	2·70	2·61	0·04	0·01	0·01	8·98	12·96	0·24	0·41	5·90	0·80	8·84
		18 in.—40 in.	Loose, friable and coarser than above	11·80	77·84	2·50	1·95	0·95	1·23	0·05	0·01	0·01	8·92	61·06	0·42	0·13	3·45	1·15	10·68
		40 in.—46 in.	Greyish brown, more compact than above	13·16	56·65	14·40	8·05	2·90	2·95	0·06	0·01	0·03	8·50	41·38	0·31	0·54	5·90	0·95	11·04
		46 in.—60 in.	Sand	46·12	47·46	1·32	1·08	0·25	0·73	0·03	traces.	0·01	8·82	100·00	0·36	traces.	2·50	1·00	9·08
3	Area near Chak Shak Musa about 2 miles from Rajaram Railway station (Multan District)	0 in.— 8 in.	Light brownish, friable and dry	2·86	76·57	6·48	3·35	3·20	4·61	0·03	0·01	0·01	8·68	35·94	traces.	0·85	5·00	0·85	13·14
		8 in.—16 in.	Slightly darker, moister and finer textured than above	3·48	76·78	10·35	3·83	1·75	5·28	0·05	0·01	0·02	8·60	30·01	do.	0·51	5·00	1·00	7·68
		16 in.—24 in.	Finer textured than above	0·57	78·92	8·88	2·68	1·85	5·59	0·06	0·02	0·06	8·62	27·03	0·08	0·62	5·20	1·10	10·71
		24 in.—32 in.	More compact than above	1·14	60·23	17·48	9·45	3·30	5·59	0·09	0·02	0·01	8·43	25·76	0·08	0·70	6·10	1·10	10·65
		32 in.—37 in.	Moister and less compact than above	0·84	72·46	13·68	5·20	2·78	5·35	0·21	0·12	0·01	8·46	37·79	0·05	0·75	6·00	0·95	10·32
		37 in.—48 in.	Sand	1·36	87·36	3·53	0·98	0·95	2·60	0·05	0·01	0·01	8·73	26·31	0·07	0·70	4·20	1·10	12·36
4	Area near Shujabad	0 in.— 7 in.	Light brownish, fairly compact	28·62	33·87	6·85	10·20	13·45	2·97	0·04	0·01	0·01	8·67	16·95	0·28	0·82	8·45	1·15	10·28
		7 in.—18 in.	Reddish brown, less compact than above	33·28	31·31	7·25	10·55	9·68	3·35	0·04	0·01	0·04	8·78	28·71	traces.	0·95	8·35	1·15	9·09
		18 in.—25 in.	Less compact than above	57·90	26·79	2·48	2·23	4·90	1·61	0·03	0·01	0·01	8·95	24·08	do.	0·65	4·90	1·15	9·70
		25 in.—48 in.	Sandy ; loose	66·87	20·83	1·25	1·30	2·70	1·36	0·04	0·01	0·01	8·98	18·51	0·26	0·34	4·10	1·15	10·26
5	Chakanwali District Gujranwala	0 in.—12 in.	Dark brownish	38·06	31·60	7·20	7·90	10·95	0·59	0·08	0·02	0·02	7·94	21·00	0·67	0·43	8·50	0·85	10·53
		12 in.—30 in.	Somewhat redder coloured than above	25·29	29·40	12·50	10·70	19·08	0·22	0·07	0·01	0·01	7·58	16·11	0·38	0·67	8·90	1·40	9·25
		30 in.—48 in.	Soil with free water and reddish streaks due to high watertable	21·97	25·76	13·50	15·33	18·13	0·47	0·06	0·01	0·01	7·90	11·31	0·52	0·53	11·00	1·60	7·69
6	Moza Jalianwali Jalokan near R.D. 429000 Burala Branch extension	0 in.—2½ in.	Light brownish, compact	0·33	35·54	24·28	21·53	11·08	3·23	0·39	0·04	0·32	8·08	5·66	0·56	0·04	15·40	0·60	3·62
		2½ in.—12 in.	Chocolate brown with reddish streaks	0·97	46·14	17·45	18·18	8·73	4·33	0·31	0·05	0·21	9·14	95·77	2·11	0·69	14·10	2·00	14·36
		12 in.—20 in.	Reddish brown ; compact	0·22	42·59	23·48	17·93	9·55	3·48	0·43	0·08	0·30	8·76	40·84	1·49	0·26	10·30	2·30	12·20
		20 in.—39 in.	Greyish brown, sandy	0·23	70·60	12·65	8·50	5·10	1·73	0·17	0·04	0·09	8·44	25·49	0·85	0·43	3·60	2·15	18·44
		39 in.—48 in.	More compact and moister than above	0·24	47·61	23·35	16·53	8·63	2·12	0·12	0·01	0·04	9·12	22·60	2·08	0·37	5·30	2·25	24·50

TABLE IV

Analytical results of soil profiles from areas under lani (Suaeda furticosa)

Serial number	Location	Depth of horizons	Soil characteristics	Results of mechanical analysis					Percentage of calcium carbonate content	Chemical analysis of water extracts			pH	Dispersion co-efficient	Exchangeable base content in milli-equivalents				Degree of alkalisation
				Percentage of sand	Percentage of fine sand	Percentage of silt	Percentage of fine silt	Percentage of clay		Percentage of total solid	Percentage of chlorides as NaCl	Percentage of sulphate as Na_2SO_4			Na	K	Ca	Mg	
1	Malikpur Tori District Shaikhupura	0 in.— 4 in.	Light brownish, not very compact	7·11	31·20	23·10	21·15	9·20	2·62	1·46	0·83	0·96	9·76	100·0	6·75	2·75	traces	1·45	86·74
		4 in.—16 in.	Darker coloured and more compact than above	1·19	33·60	19·23	28·13	16·98	3·62	0·19	0·02	0·01	10·15	100·0	4·43	0·82	1·35	1·10	68·20
		16 in.—24 in.	As above but somewhat more compact.	0·71	16·94	19·05	39·03	17·18	2·66	0·13	0·02	0·01	9·87	76·72	4·01	1·44	0·85	2·90	59·24
		24 in.—36 in.	Lighter in colour and less compact than above	6·73	37·20	22·80	25·08	10·68	2·20	0·11	0·01	0·01	9·64	46·82	2·01	1·69	2·50	2·50	42·53
2	Bakh Kallar Sirkar near Sahiwal District, Shahpur	0 in.— ¼ in.	Scaly soil surface layer .	2·45	17·22	22·40	32·45	9·18	8·39	0·02	0·02	0·01	9·18	44·94	2·29	0·46	8·90	1·40	21·08
		¼ in.— 8 in.	Light brownish compact	8·81	26·70	15·90	22·08	14·33	6·81	0·13	0·02	0·01	9·71	52·00	4·10	1·00	9·90	1·10	31·68
		8 in.—13 in.	As above but somewhat lighter coloured	5·38	14·95	16·20	13·50	16·95	6·96	1·08	0·13	0·87	9·49	100·00	3·91	0·11	4·85	1·80	37·67
		13 in.—27 in.	Compact, contains *kankar* nodules	13·59	11·67	11·28	26·10	25·18	5·08	0·79	0·14	0·59	9·68	93·47	6·40	1·20	2·35	2·75	59·84
		27 in.—48 in.	Compact, contains bigger-sized *kankar* nodules	17·19	11·27	8·75	24·90	25·35	6·15	0·39	0·11	0·16	9·85	100·00	5·19	2·71	3·15	2·65	57·66
	Mirdad Muaffi District Montgomery	0 in.—2½ in.	Greyish brown . .	0·27	48·25	8·55	12·80	22·65	2·23	1·16	0·66	0·51	8·97	44·15	4·38	2·12	4·28	0·55	57·38
		2½ in.—11 in.	Brownish, more compact	0·22	48·90	9·60	13·68	20·93	2·13	0·57	0·25	0·32	9·48	90·80	5·31	2·41	1·28	1·95	70·48
		11 in.—22 in.	As above but more compact	0·34	51·08	9·60	13·18	17·35	3·05	0·53	0·17	0·34	9·41	53·75	2·43	2·02	2·56	2·30	47·81
		22 in.—33 in.	Lighter coloured and less compact than above, contains *kankar* nodules	0·20	52·42	9·80	13·00	12·80	4·60	1·15	0·18	0·95	9·11	16·40	4·39	2·73	6·60	1·05	48·21
		33 in.—48 in.	Less compact and contains less *kankar* nodules than above	0·16	53·12	8·73	11·80	14·10	5·93	0·83	0·20	0·61	9·24	35·11	2·34	3·43	2·68	1·40	58·58

TABLE V

Analytical results of soil profiles from areas devoid of any vegetation

Serial number	Location	Soil characteristics	Depth of horizons	Results of mechanical analysis					Percentage of calcium carbonate content	Chemical analysis of water extracts			pH	Dispersion co-efficient	Exchangeable base content in milli-equivalents				Degree of alkalisation
				Percentage of sand	Percentage of fine sand	Percentage of silt	Percentage of fine silt	Percentage of clay		Percentage of total solids	Percentage of chlorides as NaCl	Percentage of sulphates as Na_2SO_4			Na	K	Ca	Mg	
1	Rakh Kallar Sirkar near Sahiwal, District Shahpur.	0 in.—½ in.	Scaly soil surface layer	4·14	29·38	21·03	20·63	13·15	8·19	0·13	0·02	0·03	9·07	36·68	2·67	0·33	18·00	1·70	13·22
		½ in.—3½ in.	Brownish, compact	4·15	21·72	13·05	27·30	19·65	5·29	0·61	0·06	0·33	9·64	43·13	3·55	1·85	11·20	1·70	29·51
		3½ in.—26 in.	Dark brownish, very hard and compact	1·74	10·03	14·55	37·62	22·22	8·04	0·51	0·04	0·16	9·82	100·00	5·71	1·79	12·80	1·85	33·86
		26 in.—48 in.	As above but moister and less compact	3·37	31·45	9·00	20·00	23·35	7·08	0·23	0·92	0·02	9·64	100·00	6·74	1·96	10·05	2·05	40·18
2	Mirdad Muaffi Montgomary District.	0 in.—½ in.	Greyish brown, soft with honey-comb structure	0·34	39·66	9·40	12·03	30·33	2·25	0·84	0·46	0·31	9·28	100·00	9·78	3·12	1·92	2·75	73·44
		½ in.— 7 in.	Brownish, more compact than above	0·14	48·16	11·55	14·70	18·05	2·13	1·18	0·55	0·48	9·70	99·73	10·53	2·12	0·32	2·10	83·94
		7 in.—18 in.	As above, but more compact	0·10	51·78	10·75	13·58	15·60	2·13	0·99	0·41	0·32	9·79	33·01	10·31	1·89	2·52	1·95	73·20
		18 in.—32 in.	As above, but more compact	0·08	52·34	10·80	13·25	17·90	2·00	0·61	0·24	0·09	10·90	23·18	10·59	2·51	0·90	1·90	82·40
		32 in.—48 in.	Softer and moister than above	0·09	50·68	11·15	14·75	19·25	1·50	0·43	0·14	0·07	10·00	28·70	12·11	1·59	1·10	2·30	80·12

TABLE VI

Comparative statement showing the variation of the main soil characteristics of soils under different natural surface flora and areas devoid of vegetation

Serial number	Soil characteristics	*Harmal*	*Ak*	*Sarkanda*	*Lani*	Devoid of vegetation
1	Mechanical composition	Contents of clay and silt fractions vary from 8—17 per cent and 19—40 per cent, clay decreasing with depth at majority of sampling sites	Soils preponderatingly sandy, the sand at majority of sampling sites being of fine variety. Clay content low varying between 2—10 per cent	Soils very sandy, in some horizons sand being as high as 90 per cent. Clay content very low especially in the low portion of the profile except at site V	Soil composition more or less like normal soils of the area	Soil composition more or less like normal soils of the area
2	Percent soluble salt content	Invariably low in the top portion but increases in the lower portion of the profile. The presence of nitrates in soils is peculiar to this flora	Low throughout the profile	Low throughout the profile	High throughout the depth of the profile, higher in top few inches, then slight decrease and then increase with depth	Either higher or lower than soil under *lani*
3	*p*H	Quite low and decreases with depth	Fairly low	Higher than those of soils under *harmal*	Above 9·2 in almost all the horizons, varying little with depth	Very high with a tendency to increase with depth
4	Dispersion co-efficient	Quite low particularly in bottom horizons	Fairly low	Low	High especially in the lower horizons of the profile	Very high in the top and relatively less in the lower horizon of the profile
5	Per cent calcium carbonate content	High, increases with depth at the majority of sites	Fair, with a tendency to increase with depth at the majority of sites	Quite appreciable at some of the sites	Quite high	Quite high at one site low at the other
6	Content of bases in the exchange complex	(Na+K) quite low, Ca fairly high especially in the lower horizon of various profiles	Na+K low, Ca low at two sites but high at others, per cent $CaCo_3$ content of the latter quite high	Na+K low, Ca high in top portion decreasing in lower portion	Na+K markedly high as compared to Ca	Na+K maximum out of all sites and high throughout the depth of profile. Ca very low
7	Degree of alkalization	Fairly low throughout the depth	Fairly low	Low	High	Consistently high throughout the depth

TABLE VII

Harmal *area employed for the manufacture of nitre*

Depth of sampling	Percentage of total dissolved solids	Chlorides expressed as per cent of NaCl	Sulphates expressed as per cent of Na_2SO_4	Nitrates expressed as per cent of $NaNO_3$	*p*H
0-6 in.	1·60	0·33	1·15	0·052	8·26
6 in. -12 ft.	1·20	0·04	1·27	0·001	7·58
2 ft.-3 ft.	0·55	0·04	..	0·003	7·70
3 ft.-4 ft.	0·88	0·05	0·63	0·001	7·58
4 ft.-5 ft.	0·27	0·04	0·13	0·002	8·14

It is brought out in Table VI that nitrate content of the top six inches soil is appreciable. Its contents can be expected to be higher in the surface scrapping actually used for nitre production.

Harmal seems to indicate soil good in other respects but with salts in the soil crust. It may therefore be expected that due to moisture movement by capillarity and evaporation at soil surface, these salts would concentrate in the top soil and adversely affect the crop yield.

Ak represents a type of an extremely light sandy soil with low salt, clay content and *p*H. Such soils would naturally have poor water holding capacity and manifest low productivity.

Soils under *sarkanda* are, again generally poor. They, however, manifest so much variation in their soil characteristics that in their case the poor quality might be attributed to a variety of causes, e.g. sandy nature (sites II and III), high salt content (sites I and VI), high *p*H (sites IV and VI), high water table (site V), etc. That flora is generally associated with high water table either continuous or occasional and soil of rather inferior quality due to various causes.

Soil under *lani* indicates a fairly advanced stage of deterioration and is unproductive. Such soils would need intensive reclamation operations before their economic cultivation can be assured.

Bare land devoid of any vegetation belongs to the hard *rakkar* type. The soil is very closely packed and intractable so that while riding on such land an almost metallic sound is produced. During bright sunshine one usually observes the phenomenon of mirage. The soil usually breaks into hexagonal clods and is highly charged with alkali and salts. If water is applied the soil mulches and is

rendered almost impervious. As appears from the field behaviour and the results of various analyses, such land represents the final stage of soil deterioration. Its reclamation requires a long drawn technique, considerable patience and experience.

Summary

Certain types of natural flora are known to thrive on particular soils and are either entirely absent or manifest very poor development at places with different soil features. Moreover, certain progressive changes in the various soil characteristics taking place in the course of soil deterioration are accompanied by a definite change in the surface vegetation. Certain types of natural flora may, therefore, serve as an index of the changing soil conditions during the salinization or alkalization of land. A study has been made of soils from typical areas colonised by four types of natural flora and land devoid of any vegetation. It has been shown that :

Harmal indicates soil of a rather normal texture but having a fairly high content of salts in the profile. Nitrates are conspicuously present in that soil. With the application of irrigation and subsequent moisture movements, evaporation, etc. the salts tend to move towards the surface resulting in a relative decline in the crop yield. Such areas, when put under cultivation, have therefore to be particularly watched.

Ak usually establishes on extremely light sandy soil which, otherwise, has very low salt content and alkalinity. Such soils are expected to manifest poor capacity of moisture retention and low productivity.

The presence of *sarkanda* as surface vegetation indicates a fairly high water table, either continuous or occasional and rather a very wide variation in the nature of the main soil characteristics, all of those factors contributing to low productivity.

Soil from areas colonised by *lani* is generally in a fairly advanced stage of deterioration and would therefore be expensive and fairly difficult to reclaim to a stage fit for economic cultivation. That type of flora seem to represent one stage prior to the culmination of the process of soil deterioration when the land becomes completely devoid of vegetation. The reclamation of the latter area is extremely difficult, expensive and requires considerable patience and experience.

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EFFECT OF TRENCH MANURING ON THE PHYSICO-CHEMICAL NATURE OF THE SOIL AND ITS RELATION TO CROP YIELD

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(With Plate VII and three text-figures)

CONTINUOUS field experiments at Rothamsted and Woburn, England have definitely proved that the farm-yard manure is the best organic manure. To secure good crops repeated dressings of farm-yard manure are to be resorted to over the fields. In India, this method has certain disadvantages, for the manure gets washed off by torrential rains during monsoon seasons.

Trenching of the manure in pits has been used in horticultural practices since long. It is the usual practice in India, in sugarcane cultivation, to apply the manure in trenches. Russell [1937] reports to have tried trenching of the vegetable matter with success in improving the soil texture in some gardens.

Higginbottom [1945] quotes a highly significant difference in crop yield obtained from trenching the city refuse in Ratalam State (India) by Bernard Coventery. Similar results were obtained in the Government Military Grass Farm, Allahabad and at Naini Central Jail, Allahabad.

Trenching of the manure has been practised in Europe for many years past and to a small extent in the United States of America. It was described for the growth of hops in the beginning of this century in Europe. In France, it was used in vineyards where manure was placed in trenches and covered over.

Cropping history of the experimental area

The land under experimentation, was purchased by the Agricultural Institute in 1912 and since then was used as a students' plot for growing vegetables. It was irrigated by a tube-well and manured from time to time. The well failed in 1925 and thereafter, it was given sullage irrigation till 1935, when that was stopped. In 1937, that area was set aside for dry farming experiments. In 1939 trenching operations were done under the direction of Higginbottom during May to July. Those consisted of trenching the farm refuse by digging the fields about one foot and burying the fresh cowdung in the subsoil layers and then covering it over by 6 in. of the soil. He used six replications and three treatments on a piece of level land. Each plot was 22 ft. × 88 ft. and there was a 2 ft. path between the blocks, consisting of four plots (three treatments and one check plot). Thus, the whole lay out of 24 plots was 538 ft. × 88 ft. (Fig 1).

The experiments were conducted to test the efficiency of trenched manure in comparison with the usual types of farm-yard manure (rotted cowdung and farm

* It is a matter of deep regret that junior author while conducting field trials of one of his experiments during May 1949 suddenly got an attack of sun-stroke and died in hospital within a week of the stroke.

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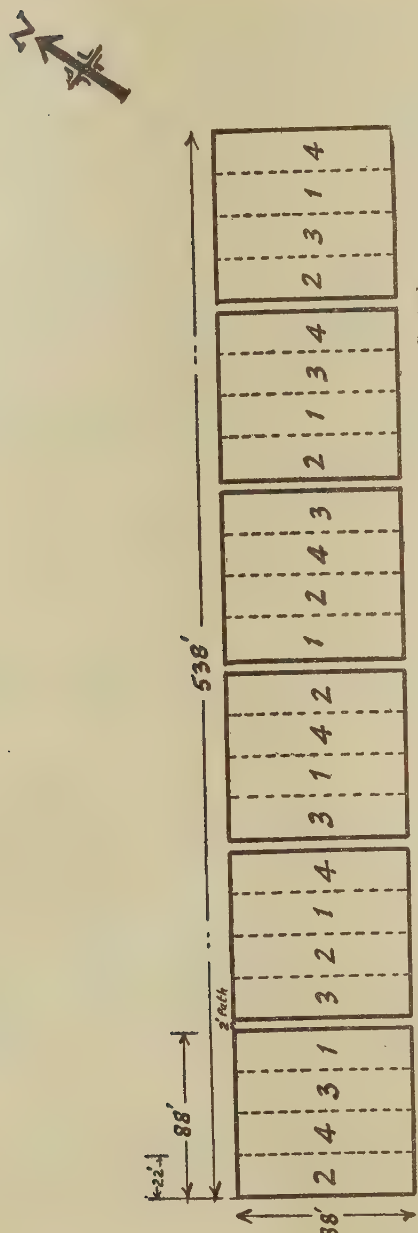

1=Trenched manure.

2=Farm yard manure.

3=Control.

4=Green manure.

FIG. 1. Lay out of the trenched manure experiment

refuse) spread over the fields and the green manure (ploughed under). Therefore, three manurial treatments with one check plot (no manure plot, also called 'control') was included in one block lay out. Two hundred tons of fresh cowdung directly from the cowshed was buried in the six randomized plots in the lay out. The total area of the six plots of 88 ft. × 22 ft. each, in which the manure was buried was 0·27 acre. Farm-yard manure (at 100 lb., of nitrogen equivalent per acre) was spread over the six randomized farm-yard manure plots and *sanai* (*Crotalaria juncea*) was sown and ploughed under, just before flowering, in the green manure plots. Manuring was done, only once, in September 1939. The trenched manure plots did not allow any plant growth till the fresh cowdung buried in the plots, got rotted and the soil reaction came within the limits of plant toleration. As the field could not be irrigated mainly fodder crops namely, *bajra* (*Pennisetum typhoideum*) and *jowar* (*Andropogon sorghum*) were sown in it during the rainy seasons in 1940, 1942, 1944, 1946 to take yield trials. Nothing was grown during the winter in the above stated years and it was left fallow throughout the year in 1943 and 1945. Only in 1947, at the initiation of the authors, barley was sown in winter as a *rabi* crop.

Statistical analyses of yield data (Table IA) showed that in all the five trials done in 1940, 1942, 1944, 1946 and 1946-47, the trenched manure plots showed significantly higher yields than the other treatments which were not significantly different from one another. The trenched manure plots were not only distinctly superior in plant growth to other treatments but they produced more than the normal yield in India.

The first four trials were conducted by the authorities of the Agricultural Institute, Allahabad. The yield trials in 1946-47 were conducted by the authors and the physico-chemical determinations were done in the Botany Department, Allahabad University, Allahabad.

Methods

Soil samples were taken with the help of a soil auger at two depths, one at 0 in. to 6 in. and the other at 6 in. to 12 in., characterized as 'surface' and 'sub soils' respectively. Samples were prepared according to the directions in *Methods of Analysis* (A. O. A. C.) in 1940. Moisture studies were done as given by Wright, in *Soil Analysis* [1937]. Moisture equivalent was determined by Bouyoucos method [1929] using a standard Buchner funnel of 4·3 cm. diameter and 2 cm. depth. Apparent density was determined by packing the air dry soil in a 25 ml. flask and true density was determined in the same flask by the displacement of water. For organic carbon and nitrogen Bangor's method was employed. The organic nitrogen was estimated by using Nessler's reagent and matching the colour by the Hellige Dubosque comparator. Available nitrogen was estimated as ammoniacal nitrogen by magnesia method and total inorganic nitrogen by the Devarda's alloy. Available phosphorus was estimated by following Troug's method [1930]. Available potassium was estimated in the two per cent citric acid extract following Piper's cobalt-nitrite method. The hydrogen ion concentration was determined by developing colour with the B. D. H. standard indicators and comparing with Hellige colour

M 2

TABLE IA

Analysis of variance for Table I

Mean sum of squares

Due to	D.F.	Weight of green fodder			Weight of dry fodder	Weight of heads			Weight of grains
		Bajra (1940)	*Jowar* (1944)	*Jowar* (1946)	*Jowar* (1942)	*Jowar* (1942)	*Jowar* (1944)	*Barley* (1947)	*Jowar* (1942)
Blocks	5	10539·69	119·60	91·057	13309·51**	805·15*	19·153*	58·70**	292·77
Treatments	3	191511·77**	175698·77**	249779·83**	115199·98**	2727·91**	567·233**	3040·89**	2587·29**
Error	15	5958·04	85·80	193·78	2271·01	179·03	6·014	11·55	214·76
Total	23								

Treatments, means and critical difference for Table I

Trenched manure	(Tm.)	722·30	465·30	514·10	426·25	82·5	47·46	64·25	62·0
Farm yard manure	(Fym.)	326·20	119·16	109·80	161·50	29·4	22·0	7·0	21·3
Control	(C.)	386·60	118·30	103·50	173·50	31·66	30·8	6·08	24·6
Green manure	(Gm.)	376·60	132·50	104·90	122·58	23·25	23·5	5·33	17·0
C. D. at 5 per cent		94·965	11·4008	17·11	58·602	16·451	2·43	4·176	18·028
Conclusion		Tm> *C; Gm ; Fym*	Tm> *G m ; Fym ; Gm*	Tm > *Fym ; Gm ; C*	Tm > *C; Fym; Gm*	Tm> *C; Fym; Gm*	Tm> C ; *Fym; Gm*	Tm > *Fym; C ; Gm*	Tm> *C; Fym ; Gm*

* Significant at one per cent level.
** Significant at five per cent level.

discs. Preliminary studies to test the comparative richness of the soil extract for the healthy growth of the micro-organisms, were done in soil extract agar, using different soil samples as inoculants. The high mortality of barley plants incited preliminary pathological studies.

Vigour was estimated by allotting marks for each plot according to the comparative amount of growth ; excellent—6, very good—5, good—4, fair—3, bad—2, very bad—1.

Experimental findings

Table I

Results of the yield trials from 1939 to 1947

(Total yield of six plots expressed in lb. per acre)

Weight	Year	Trenched manure	Farmyard manure	Control	Green manure
Weight of the green fodder in lb.	1939 (*Bajra*)	..	4589·86	6570·73	*Sanai* sown
	1940 (*Bajra*)	16262·66	7343·33	8704·44	8480·30
	1944 (*Jowar*)	10240·15	2682·92	2664·16	2983·11
	1946 (*Jowar*)	11566·73	2669·34	2328·72	2360·59
Weight of dry fodder in lb.	1942 (*Jowar*)	9595·49	3637·89	3906·19	2759·84
Weight of the heads in lb.	1942 (*Jowar*)	1857·41	662·28	712·94	523·45
	1944 (*Jowar*)	1110·69	495·30	816·77	529·08
	1946-47 (Barley)	1445·6	157·5	136·9	199·99
Weight of the grain in lb.	1942 (*Jowar*)	1395·87	480·3	617·26	382·73

TABLE II

Vigour estimate of the crops sown in different years

(Total of six plots)

	1940 (*Bajra*)	1942 (*Jowar*)	1944 (*Jowar*)	1946 (*Jowar*)	1946-47 (Barley)
Trenched manure	31·50	30·00	32·50	33·25	34·75
Farm-yard manure	15·50	13·25	14·00	8·50	5·00
Control	19·00	17·50	13·50	8·25	4·50
Green manure	19·50	12·00	13·00	8·00	4·00

TABLE III

Total population of jowar *plants in October 1946*

	Trenched manure	Farm-yard manure	Control	Green manure
Total of six plots	10528	5772	5225	5747

TABLE IIA

Analysis of variance for Table II and III

Mean sum of squares

Due to	D. F.	*Bajra* (1940)	*Jowar* (1942)	*Jowar* (1944)	*Jowar* (1946)	Barley (1946-47)	Population of *Jowar* 1946
Blocks	5	3·6563*	6·472**	0·0797	0·3541*	0·9401**	1·7778
Treatments	3	4·8729**	3·35*	9·5139**	26·0301**	38·1554**	61·8097**
Error	15	0·85480	0·76	1·1512	0·08147	0·1679	0·7474
Total	23						

Treatment means and critical difference for Table II and III

	Bajra (1940)	*Jowar* (1942)	*Jowar* (1944)	*Jowar* (1946)	Barley (1946-47)	Population of *Jowar* 1946
Trenched manure	5·2	5·0	5·40	5·54	5·76	175·4
Farm-yard manure	2·6	2·2	2·33	1·42	0·83	96·2
Control	3·2	2·9	2·25	1·37	0·75	87·1
Green manure	3·2	2·0	2·16	1·33	0·66	95·8
C. D. at 5 per cent	1·137	1·0718	1·319	0·351	0·1593	11·12
Conclusion	Tm>*Gm* ; *C* ; *Fym*	Tm>*C* ; *Fym* ; *Gm*	Tm>*Fym* ; *C* ; *Gm*	Tm>*Fym* ; *C*;*Gm*	Tm>*Fym* >*Gm* ; /*C*	Tm>*Fym* ; *C* ; *Gm*

* Significant at one per cent lavel.
** Significant at five per cent level.

Discussion

The data for the yield of crops (Table I) establishes the superiority of the trenched manure treatments in comparison to farm-yard manure and green manure treatments. The vigour and the population of the crops are given in Figs. 2 and 3. This gives a clearer analysis of the data of the experiments at a glance, than Tables II and III. Not a single plant of *jowar* in 1946 was as tall and healthy in the farm-yard manure and control plots as in the trenched manure plots (Fig. 2). The histograms in Fig. 3 represents the total population of *jowar*. There is a high significant difference between the trenched manure plots and the rest (Table IIA). For, whereas the population ranges above 10,000 in the trenched manure plots, it is less than 6,000 in other treatments.

The vigour estimates of the barley plants during the dry winter season were interesting. Barley was sown on 23 November 1946. The germination was equal in all the treatments. But, with the passage of time, plants began to die in all the plots except the trenched manure ones. By 13 February 1947, there were very few plants left in the former plots and they looked barren. The trenched manure plots, however, did remarkably well showing luxuriant growth. Figs. 1 and 2 (Plate VII) show the contrast.

The physico-chemical determinations, give us some clue in explaining the significant differences in yield, growth and vigour of the crops sown during these years in the different treatments.

Statistical analyses of the data for moisture content of (*a*) the air dry soil, (*b*) saturated soil and (*c*) moisture equivalent (Table IVA) showed high significant differences between the treatments. The trenched manure plots were far superior to the rest while the farm-yard manure, green manure, and control plots were not significantly different ; except that in the moisture content of air dry soil green manure treatment was inferior most. All these values were higher, for the subsoils than for the surface soils in the trenched manure plots while reverse was the case with the other treatments. This can be attributed to the higher organic matter content of the subsoils of the trenched manure plots in contrast to the other plots where normally there is more organic matter in the surface soils due to the decomposition of plant material.

The soils from the trenched manure plots suffered greater loss on ignition, which indicated a higher organic matter and colloidal content than other plots.

Due to the higher organic matter content the true density and apparant density of the trenched manure plots was lower than those of the other treatments and this consequently increased the pore-space. Stephenson [1918] has shown that, the surface area of the particles of the humus soil is twice that of the sandy soil. Higher value for pore-space may be due to disturbing the soil during trenching, as Fauser [1935] has shown that the pore-space in the disturbed subsoils between the drains was considerably greater even after 25 years. This high pore-space in the soil allows better aerobic respiration of the roots and their free growth, which

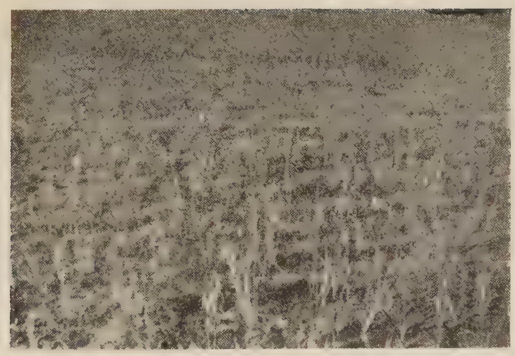

FIG. 1. Closer view of the trenched plot in block II showing luxurient growth of barley

FIG. 2. Few plants in the control, farmyard manure and green manure

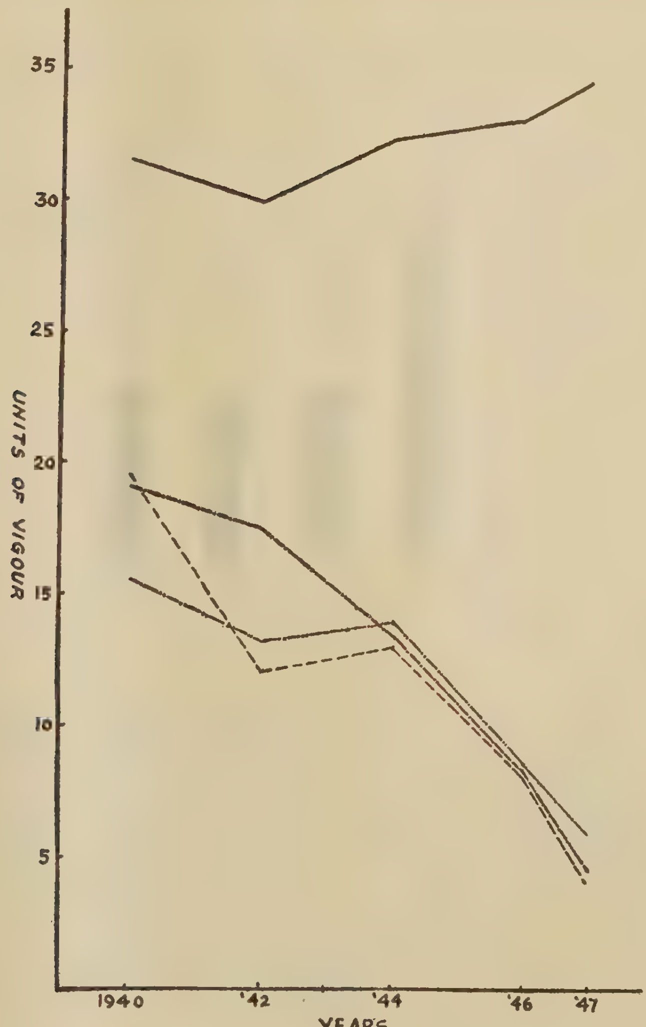

FIG. 2. Graph of the vigour estimate of the crops (*vide* Table II).

——————————trenched manure.

——————————farm-yard manure.

——————————control.

——————————green manure,

N

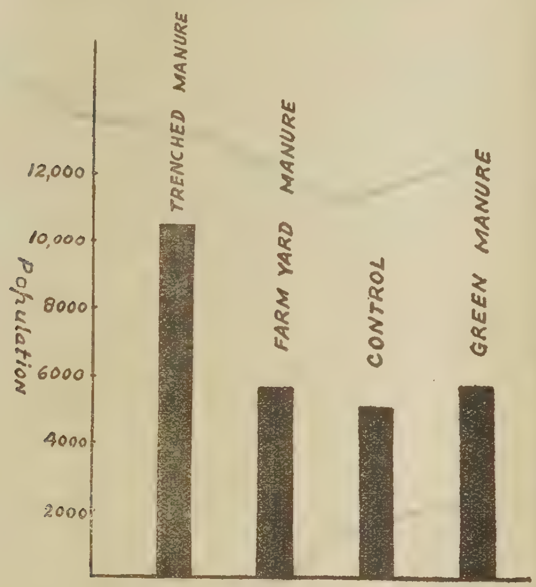

FIG. 3. Total population of the *jowar* plants (*vidé* Table III).

facilitates the absorption of the nutrients from the soil and hence better plant growth.

The chemical analyses to estimate the main plant nutrients present in the soil showed all round superiority of the trenched manure plots. The statistical analyses of the data for ammoniacal nitrogen, nitric nitrogen, total soluble nitrogen, total organic nitrogen, organic carbon, and available phosphorus Table VIA showed a highly significant difference, between the treatments. In these chemical constituents, the trenched manure plots were far superior to the other treatments, which were not significantly different ; except that in the total organic nitrogen content farm-yard manure and green manure plots were even inferior to control plots.

The *p*H of the soil in the trenched manure plots was between 7·2 and 7·5 while in the case of others it was more alkaline between 7·6 and 7·9. Mc George [1945] has shown that at *p*H 7·6 to 7·9 phosphorus is fixed in the non-available form. This may be one of the reasons of lower value for available phosphorus in the farm-yard manure, green manure and control plots.

The experiments to test the extent of micro-biological population and their activity showed that the soils of the trenched manure plots contained higher population of micro-organisms, and the soil extract of the soils of the trenched manure plots allowed more efficient activity of micro-organisms.

TABLE IV

Moisture studies of the soils

(Averages of six determinations-expressed as percentages of oven dry soil)

	Moisture content of the air dry soil	Moisture content of saturated-soil	Moisture equivalent	Loss on ignition
Trenched manure—				
Surface soil 0 in. to 6 in.	1·688	47·88	30·06	2·865
Subsoil 6 in. to 12 in.	1·921	48·29	29·42	3·284
Farm yard manure—				
Surface soil	1·415	42·32	28·38	2·401
Subsoil	1·622	36·61	27·44	2·085
Control—				
Surface soil	1·403	42·17	28·23	2·389
Subsoil	1·611	36·35	27·33	2·083
Green manure—				
Surface soil	1·405	42·18	28·39	2·408
Subsoil	1·593	36·56	27·40	2·095

Table IVA

Analysis of variance for Table IV

Mean sum of squares

Due to	D.F.	Mean. Moisture content of air dry soil	Sum of Moisture content of saturated soil	Squares Moisture equivalent
Blocks	5	0·000446	0·18176	0·1957
Treatment	3	0·26502**	227·9772**	10·6879**
Error (1)	15	0·000583	0·22325	0·2395
Soils	1	0·52417**	209·5334**	9·1438**
Soil * Treatment—	3	0·000886**	21·08775**	0·0802
Error (2)	20	0·010576	0·1447	0·1017
Total	47			

Treatment means and critical difference

Trenched manure	1·80409	48·09	29·75
Farm-yard manure	1·51175	39·47	27·91
Control	1·50675	39·27	27·78
Green manure	1·4990	39·37	27·89
Critical difference	0·00667	0·41128	0·425
Conclusion	Tm>*Fym* ; *C*>*Gm*	Tm>*Fym* . *C* ; *Gm*	Tm>*Fym* ; *Gm* ; *C*

Table V

Density and pore-space

(Totals of three determinations each)

		True density	Apparent density	Pore-space
Trenched manure— Surface soil	0 in. to 6 in.	2·483	1·557	37·29
Subsoil	6 in. to 12 in.	2·547	1·537	35·73
Farm-yard manure—Surface soil		2·620	1·808	30·98
Subsoil		2·628	1·835	30·18
Control— Surface soil		2·630	1·874	28·71
Subsoil		2·631	1·841	30·01
Green manure— Surface soil		2·614	1·843	29·48
Subsoil		2·597	1·763	30·27

* Significant at one per cent.
** Significant at five per cent.

TABLE VI

Chemical constituents of the soils

(Expressed as percentages of the oven-dry soil)

—	Ammoniacal nitrogen-average of six determinations	Nitric nitrogen average of six determinations	Total soluble inorganic nitrogen average of six determinations	Total organic nitrogen average of six determinations	Organic carbon average of six determinations	Organic matter calculated by multiplying organic C × 1·724	Phosphorus average of six determinations	Potassium average of three determinations	Hydrogen-ion concentration (pH)
Trenched manure—									
Surface soil o in. to 6 in.	0·00366	0·00667	0·01034	0·0772	0·7699	1·324	0·0761	0·01190	7·3—7·5
Subsoil 0 in to 12 in.	0·00290	0·00604	0·00895	0·0877	0·9050	1·562	0·0962	0·01660	7·2—7·4
Farm-yard manure—									
Surface soil	0·00037	0·00269	0·00306	0·0533	0·5381	0·874	0·0396	0··00929	7·6—7·8
Subsoil	0·00021	0·00234	0·00255	0·0433	0·4800	0·751	0·0276	0·00738	7·5—7·8
Control—									
Surface soil	0·00064	0·00246	0·00309	0·0536	0·5433	0·935	0·0416	0·00930	7·6—7·8
Subsoil	0·00036	0·00216	0·00252	0·0458	0·4575	0·787	0·0269	0·00738	7·5—7·6
Green manure—									
Surface soil	0·00048	0·00234	0·00281	0·0547	0·5530	0·952	0·0432	0·00939	7·6—7·9
Subsoil	0·00031	0·00210	0·00240	0·0487	0·4931	0·850	0·0265	0·00726	7·8—7·9

TABLE VIA

Analysis of variance for Table VI

Mean sum of squares

Due to	D.F.	Ammoniacal nitrogen	Nitric nitrogen	Total soluble nitrogen	Total organic nitrogen	Organic carbon	Organic matter	** Phosphorus
Blocks	5	0·4085 × 10—6	9·834 × 10—6**	2·2915 × 10—6*	51·96 × 10—6	0·008191	0·015926	11·08 × 10—6
Treatments	3	25·086 × 10—6**	484·15 × 10**—6	142·9402 × 10—6*	3226·77 × 10—6**	0·321044**	1·010779**	8086·86 × 10—6**
Error (1)	15	0·3461 × 10—6	0·813 × 10—6	0·592 × 10—6	46·93 × 10—6	0·003361	0·016301	94·8 × 10—6
Soils	1	1·4077 × 10—6	16·912 × 10—6	6·1417 × 10—9*	119·7 × 10—6	0·004746*	0·244515**	404·26 × 10*—6
Soils × treatments	3	0·0314 × 10—6	0·58 × 10—6	0·622 × 10—6**	60·53 × 10—6	0·030996*	0·0376367	904·89 × 10—6**
Error (2)	20	0·7309 × 10—6	0·651 × 10—6	0·0842 × 10—6	61·59 × 10—6	0·002889*	0·010353	64·6 × 10—6
Total	47							

Treatment means and critical difference for Table VI

	Ammoniacal nitrogen	Nitric nitrogen	Total soluble nitrogen	Total organic nitrogen	Organic carbon	Organic matter	Phosphorus
Trenched manure	0·00328	0·00632	0·00964	0·0825	0·837	1·443	0·0864
Farm-yard manure	0·00029	0·00252	0·00280	0·0481	0·509	0·833	0·0336
Control	0·00050	0·00231	0·00280	0·0497	0·500	0·862	0·0343
Green manure	0·00039	0·00223	0·00262	0·0435	0·524	0·901	0·0349
C. D. at 5 per cent	0·0005	0·000788	0·004006	0·00596	0·0487	0·111	0·0029
Conclusion	Tm > *C* ; *Gm* ; *Fym*	Tm > *Fym* ; *C* ; *Gm*	Tm > *Fym* ; *C* ; *Gm*	Tm > C > *Fym* > *Gm*	Tm > *Gm*; *Fym*; *C*	Tm > *Gm*; *Fym*; *C*	Tm > *Gm* ; *C* ; *Fym*

* Significant at one per cent.
** Significant at five per cent.

The rest of the soils were very poor in their micro population and their soil extracts did not supply enough food for efficient micro-biological activity. The higher amounts of ammoniacal and total soluble nitrogen in the surface and subsoils of the trenched manure plots may be attributed to the higher micro population in them which was sustained due to the higher amount of bacterial food incorporated by trenching the manure.

The barley plants in the farm-yard manure, green manure and control plots were highly infested with *Fusarium* sp. and other root rots. On the contrary, barley in the trenched plots showed little infection. The trenched manure plots contain more of potassium than the other treatments. It might be noted in this connection that at the Woburn Experiment Station potassic fertilizers reduced the attack of *Fusarium culmorum* on barley [Russell, 1937].

The trenched manure plots show a distinct superiority in organic matter content in the surface and subsoil layers in comparison to the other treatments. The trenching of fresh cowdung increased comparatively, the amount of organic matter in the subsoil layers and would seem to be responsible for the enrichment of organic matter and minerals in the surface soil layers also. In the other treatments, the subsoils are poorer in organic matter than the surface soils because the organic matter is added to the latter as a top dressing by the putrefaction and decay of the natural vegetation. Albrecht [1941] is of the opinion that 'organic matter merely coursing regularly through its cycle of vegetative growth, decay, and reincorporation into new crop of organic matter as a natural process, represents ion mobility, but is not a means of increasing the mass of ionic nutrients in the soil. On the contrary, it is nature's slow method of holding this mass from slipping downwards rapidly. In the humid regions organic matter is not elevator of production purely because it is of organic nature. Rather the improved fertility in terms of more calcium, more magnesium, more phosphorus, more potassium and other similar items is the means of producing a greater mass of organic matter........organic matter in the soil is the effect and not the cause of the mobile ions that represent the fertility supply of the soil'.

The results obtained at Rothamsted and Woburn [Russell, 1937] suggest that nitrogenous fertilizers over long continued experiments act more or less independently of the soil, which acts more like a cultural medium than an actual supplier of plant nutrients. In our experiments also, the significant differences in the organic matter content in the trenched manure plots have overshadowed all other differences during seven years of observations.

At Rothamsted higher amount of moisture was found in the dry season in the plots manured with farm-yard manure as compared to adjacent no manure plots [Russell, 1937]. On account of the presence of higher amount of organic matter the trenched manure plots also show a distinct superiority from the adjacent no manure plots in the moisture content of the air dry soil, moisture content of the saturated soil and the value for the moisture equivalent. Moreover, the presence of organic matter in the subsoil layers makes it puffy and lighter and improves

aeration as shown by high value for pore-space. It also prevents the formation of plough-pan not ordinarily broken by country plough.

The better air and moisture relations and enhanced micro-biological activity in the trenched manure plots result in the higher release of available nutrients, viz. nitrogen, phosphorus and potassium Presence of higher amounts of potassium has been shown to bring about more economical use of water in the soil [Russell, 1937].

The lesser amount of organic matter in the farm-yard manure, green manure and control plots brings about poor retention of moisture. But this does not act as a limiting factor during the rains as high humidity supports plant growth. During the dry winter season, however, the poorer retention of moisture becomes a limiting factor. Poor air-water relations of the soil retard the microbial activity leading to the lower release of the available nutrients in the soil. Available phosphorus and potassium have been shown to be very important during the first six weeks of the growth of barley (Hellriegel's data quoted by Russell [1937], pp. 75 and 91). The deficiency of those nutrients in the other plots caused by the above factors would seem to be responsible for the higher mortality of barley plants.

Wilsdon and Ali [1922] have shown in India that crops could be grown year after year without adding any manure under humid condition. At Rothamsted and Woburn [Voelcker and Russell, 1936] crops could be grown continuously over unmanured land. In the present experiment also *kharif* crop could be grown continuously over the unmanured land and those poor in organic matter. But during winter the *rabi* crop could not be grown over the no manure plots or over those having very low organic matter content. Figures 1 and 2, in Plate VII, of the adjacent trenched manure and no manure plots show the difference. This was true for the whole layout of the six replications. Therefore, it can be safely concluded that crops cannot be raised in India on the unmanured land or land deficient in organic matter under dry conditions. The average water content of the fertile English soils is 6 to 12 per cent [Russell, 1937] while in our soils it was only at 2 to 5 per cent. This clearly explains the limiting effect of water on plant growth.

Five yield trials during the period of seven years [1939-1947] have shown that one dose of trenched manure has repeatedly given higher yield than the other treatments. The average yield in Uttar Pradesh (India) as estimated by the Agriculture Department is 68 to 70 maunds fodder and grain per acre of *bajra* (*Pennisetum typhoideum*) and five to six maunds of *jowar* (*Andropogons orghum*) grain per acre. The figures of the yield of fodder of *bajra* and grain of *jowar* in the trenched manure plots show that it is twice the average yield.

Experiments at Rothamsted and Woburn [Voelcker and Russell, 1936] have shown that the long continuous use of farmyard manure improved the fertility relations of the soil so much so that even when the use is discontinued the plots maintain their high yield for a reasonable period of time. On the other hand, trenching of manure *only once* improved the soil to the same extent to which it would have been improved by annual manuring.

Analyses of a few random samples of wet cowdung from cowsheds of the Agricultural Institute, Allahabad, show that it contains about 85 per cent moisture. The fresh dung, on the average, contains approximately 0·4 per cent of nitrogen 200 tons of fresh cowdung was added to the trenches of 0·27 acre which means 6666·6 lb. per acre of nitrogen was added to the soil in 1939. The analysis of the soil in September 1946 shows that the trenched manure plots contain 3191·8 lb. of nitrogen per acre (taking 3460,000 lb. to be the weight of 12 in. of soil) out of which 333·196 lb. per acre is available, i.e., 0·104 part is available. In the farm yard manure, control and green manure plots there is 1768·06 lb., 1816·5 lb. and 1847·64 lb. per acre of total nitrogen respectively out of which only 0·054 part is available. This shows the superiority of trenched manure plots in releasing the available nitrogen. The trenched manure plots maintain the C/N ratio well near 10 while in other plots it varies considerably.

The yield data obtained may not be strictly comparable as the amount of nitrogen added in the different treatments was not the same (it was beyond the control of the authors ; the experiment was started independently by Dr S. Higginbottom in 1939). Still, high yield shown by the trenched manure plots continuously for seven years and definite improvement of the soil in its physical and chemical properties maintained even after seven years of application, speak in favour of the experiment. The differences in the amount of nitrogen added in the different treatments does not take away anything from the agronomic value of the experiments.

The present method involves the direct application of the cowdung to the field. This saves the farmer from the cost of removing the manure from the cowshed to the compost pits and thence to the field. As the handling of the manure is not necessary even human excreta and other waste products, e.g., kitchen refuse city refuse can be used with profit. Burying the manure prevents fly breeding and foul smell in the farm. In the present experiment the cost of trenching came to be Rs. 200 per acre (pre-war). This additional cost is more than compensated by four fold increase in yield and saves the expense and trouble on annual manuring.

Summary

Yield trials to test the efficiency of trenching the fresh cowdung and farm waste as against the green manure and the usual method of spreading the well rotted farm yard manure over the field were started in the Agricultural Institute, Allahabad in September, 1939. A Fisherian randomized block lay out with six replications was prepared on a piece of non-irrigated level land. Manure was applied only once in 1939. *Sanai* (*Crotalaria juncea*) was sown and ploughed under as green manure. The trenched manure plots did not allow plant growth in the first year.

The yield data during 1940 to 1947 show that the trenched manure plots were not only distinctly superior to the other treatments but also gave more than the normal yield in India.

The farmyard manure and green manure treatments, did not fare better than the no manure plots and in the second year of the trial deteriorated to the level

of no manure plots. Farm-yard manure was applied in the usual doses (100 lb. N equivalent per acre) and as it was not applied in the subsequent years, it seems to have been leached off or otherwise removed during the monsoon season. The green manure plots were also found not to fare better than no manure plots.

The farm-yard manure, green manure and no manure plots produced the normal yield during the rainy season, while trenched manure plots showed significantly better yield but during *rabi* (winter) season barley crop could be grown only in trenched manure plots. The unmanured plots as well as the farm-yard manure, and green manure plots were found to be incapable of producing *rabi* (winter) crops in 1947. This is in contrast with the results obtained at Rothamsted and Woburn, where even unmanured land never failed to produce crops. Water seems to be the limiting factor in the failure of *rabi* crop in India.

Physico-chemical determinations of the soil taken at two depths of all the plots show that :

(*a*) Trenched manure plots show moisture content, in (i) air dry soil, (ii) in the saturated soil and (iii) loss on ignition, greater than in other treatments.

(*b*) Trenched manure plots show lower value for apparant density and true density and higher pore-space, while reverse is the case with other treatment.

(*c*) The amount of available nitrogen (ammoniacal and nitric) total organic nitrogen, total carbon, organic matter, available phosphorus, and available potassium showed a high significant difference between the treatments ; trenched manure plot being the most superior, while others were not significantly different.

(*d*) The soil *p*H was nearer the neutral point in the T. M. plots while it was rather highly alkaline in others. At the latter *p*H phosphorus is said to get fixed in the unavailable form.

(*e*) The higher amounts of organic matter causes real difference in the two soil types and promotes micro-biological activity in significantly higher proportions in trenched manure plots while it is very poor in other treatment.

(*f*) Barley plants, though germinating quite well in all the plots, died within six weeks in all others, except in the trenched manure plots. They were found to be susceptible to the attack of *Fusarium* in those treatments.

Trenching of the manure though done only once in 1939, continued to give enhanced yield till 1947 the last experimental year. It confers to the soil the same advantages which have been shown to be obtained by the continuous application of the farm-yard manure at Rothamsted and Woburn. Yield data will be continued to be taken in subsequent years to find out the maximum period of trenched manure effect.

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YELLOW VEIN-MOSAIC OF *HIBISCUS ESCULENTUS* L.

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(With Plates VIII-X and one text-figure)

Yellow vein-mosaic of *bhendi* (*Hibiscus esculentus*) is caused by a virus and is ubiquitous in the Bombay Province wherever the crop is grown. It has not been recorded from other parts of India, though it is certain that the disease is codistributed with the host. It has recently been reported from Ceylon [Fernando and Udurawana, 1942].

In the Bombay Province, yellow vein-mosaic is a major limiting factor in the production of *bhendi*, and there is little doubt that this applies to other parts of the country. A late attack of the disease reduces the yield of fruit by over 25 per cent but when the attack is early, the crop is often a total loss.

Kulkarni [1924] first called attention to the disease being responsible for much reduction in yield of *Hibiscus esculentus*. Uppal, Varma and Capoor [1940] established its virus origin and gave it the name of 'yellow vein-mosaic'. Fernando and Udurawana [1942] described the same disease as yellow vein-banding, though the disease is characterized by clearing of the vein and there is no evidence that the veins remain green or are banded by strips of yellow tissue.

Material and methods

Plants for experiments were raised from commercial seed in insect-proof glass-houses which were periodically fumigated with Nico-fume and Corry's White-fly Death. Plants were mostly grown in 6-inch pots, but sometimes pots of larger size were used. After inoculation, plants were removed to a separate glass-house and kept under observation for at least two months.

For transmission experiments with insects, populations of insects were collected from heavily diseased *bhendi* plants in the field, and definite numbers of each species were liberated separately on healthy *bhendi* plants enclosed individually under cylindrical iron frames covered on all sides with muslin or cellophane and closed with *voil* on the top. The cellophane or muslin cages were preferred to lantern-globes, because there was no condensation of moisture in them.

Symptomatology

The first visible symptom is the clearing of small veins, which usually starts at various points near the leaf margins in about 15 to 20 days after inoculation of plants. The vein-clearing within about 24 hours of its appearance, distinguishes tself as vein-chlorosis which rapidly extends into most of the veins of the leaf

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(Plate VIII, fig. 1). New leaves developing hereafter show a homogeneous interwoven net-work of yellow veins enclosing islands of green tissue within (Plate VIII, fig. 2). The chlorosis which in the beginning is confined to the veins gradually extends into the mesophyll and occasionally a young developing leaf is completely chlorotic except for a few patches of green tissue scattered over the leaf surface (Plate VIII, fig. 3). The colour of the chlorotic areas varies from yellowish green towards the mesophyll to bright yellow near the veins. Most of the leaves on a diseased plant develop thickening of the veins on their lower sides, but no foliar growth or enations are formed.

Sometimes a few *bhendi* plants inoculated either by bud-grafting or by means of the insect vector showed remarkable suppression of vein-chlorosis, but developed profuse vein-swellings on the under sides of leaves which were thick, brittle, dark green, and curled downward (Plate IX, fig. 1). Such plants were fully infectious and the virus when transferred to healthy *bhendi* seedlings by means of the vector, induced in them the typical yellow vein-mosaic symptoms.

All growth subsequent to infection is dwarfed. Fruits produced on diseased plants are often malformed and also reduced in size (Plate, X fig. 3). They are mostly pale in colour and become tough and fibrous.

Transmission

Mechanical inoculation. The virus of yellow vein-mosaic is not transmitted by artificial inoculation of infective sap. For these tests, the inoculum was prepared by thoroughly grinding in sterile mortar with a pestle, young leaves of diseased *bhendi* plants with the addition of water at the rate of 3 c.c. to every gram of leaf material. The pulp was then strained through muslin. The sap, being highly viscid, usually imbibes lot of air bubbles during grinding and straining, and was, therefore, centrifuged for 20 minutes at 2,500 r.p.m. in order to obtain clear inoculum. In some trials 0·5 per cent sodium sulphide solution was added to the pulp, in place of water.

Inoculations were made on leaves of healthy vigorously growing *bhendi* plants by rubbing gently but firmly by means of a swab of bandage gauze soaked in the inoculum. Carborundum powder of 600-mesh fineness was used as an abrasive in all these inoculations. *Bhendi* seedlings were also inoculated by the pin-puncture method. In all cases leaves were supported on a pad of stencil rubber. Thus, in eight different inoculation tests 101 *bhendi* plants were inoculated but none of them could be diseased by sap inoculation.

Seed. During the past eight years a total of 10,700 seeds obtained from commercial dealers were planted under insect-proof conditions in the glass-house. In addition to these, 306 seeds harvested from diseased *bhendi* plants were also grown and the plants kept under observation for over two months in order to ascertain if the virus of yellow vein-mosaic was carried through the seed of *bhendi,* but no diseased *bhendi* seedling was obtained either from commercial seed or the seed harvested exclusively from diseased plants.

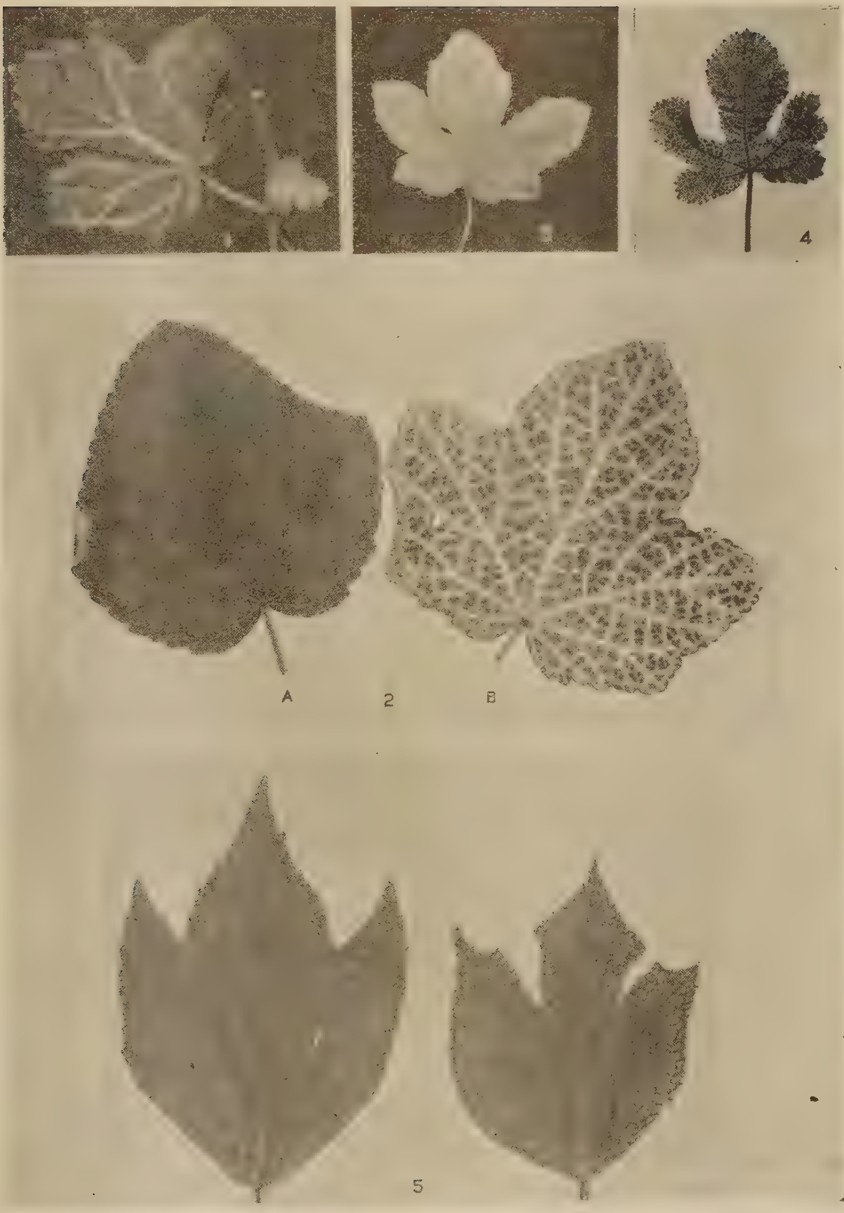

FIG. 1. A diseased *bhendi* leaf showing partial vein-chlorosis.

FIG. 2. (A) Healthy and (B) diseased leaves of *bhendi*. Diseased leaf shows homogeneous network of yellow veins enclosing islands of green tissue.

FIG. 3. A diseased *bhendi* leaf showing complete chlorosis.

FIG. 4. A leaf of naturally diseased *H. tetraphyllus* showing yellow vein-mosaic symptoms.

FIG. 5. (A) Healthy and (B) diseased leaves of *H. sabdariffa*. Diseased leaf shows thickened veins. The major veins are gnarled.

FIG. 1. A diseased *bhendi* plant showing curling and malformation of leaves, vein-swellings and general dwarfing. The plant does not show the typical yellow vein-mosaic symptoms.

FIG. 2. A typically diseased *bhendi* plant with the microcage fixed in position on one of its leaves.

FIG. 3. A plant of *Althaea rosea* diseased with the virus, showing severely malformed leaves clustered at the tip.

FIG. 4. A leaf of diseased hollyhock plant showing vein-swellings.

FIG. 5. A leaf of diseased *Hibiscus cannabinus* showing thickened veins.

FIG. 1. A plant of *Hibiscus sabdariffa* typically diseased on graft inoculation with scion of diseased *bhendi*. Leaves of the scion show typical yellow vein-mosaic symptoms, while these of *H. sabdariffa* show only thickening of veins, curling of leaves and dwarfing.

FIG. 2. A completely recovered plant of *H. sabdariffa* showing healthy looking shoots bearing normal leaves, while diseased shoots (*d*) still persist at the base.

FIG. 3. Fruits from healthy (A) and virus diseased (B) *bhendi* plants.

Graft inoculation. In order to ascertain if the yellow vein-mosaic of *bhendi* was transmitted by grafting, several plants were grafted either by wedge-or bud-grafts. The wedge-or cleft-grafts were made on vigorously growing 40-day old *bhendi* plants. The grafted plants were covered with bell jars and kept humid for about seven days in order to ensure union.

All bud-grafts on *bhendi* were made according to the 'Forkert' method described by Clair Fielden and Garner [1940]. For these trials, buds were grafted mostly at the node of the second oldest leaf of vigorously growing healthy *bhendi* plants. The grafted plants were kept under the glass-house benches in shade for three to four days. Results of these experiments given in Table I show that the yellow vein-mosaic virus is readily transmitted by grafting. The disease in the case of wedge-grafts usually appeared in about 25 days, but in bud-grafts it appeared comparatively earlier.

TABLE I

Transmission of yellow vein-mosaic disease of bhendi *by grafting*

Trial	Method of grafting	Condition of stock	Condition of scion or bud	Number of grafts made	Number of successful grafts	Number of grafted plants diseased	Number of days the disease appeared after grafting
A	Wedge-or cleft-grafts	Healthy	Diseased	16	14	14	15 to 34
B	Wedge-or cleft-grafts	Diseased	Healthy	10	6	6	20 to 30
C	Bud grafts	Healthy	Diseased	28	24	24	21 to 24

Insect transmission. Study of the insect fauna on *bhendi* plants revealed that the following insects of the order 'Hemiptera' are commonly found feeding on it:

1. *Empoasca devastans* Distant.
2. *Empoasca* sp.
3. *Aphis gossypii* Glover.
4. *Bemisia tabaci* Genn. (*B. gossypiperda* M. & L.)*

Of the two species of jassids, *Empoasca devastans* was always found to be more abundant and was collected more frequently and in larger numbers than *Empoasca* sp. The aphid was also very common during the monsoon and winter months and often caused a temporary crumpling of younger leaves which become normal soon after the aphid migrated to still younger leaves.

The white-fly, *Bemisia tabaci* Genn., is a well known pest of cotton in North India and its occurrence on *Hibiscus esculentus* has also been recorded by Hussain

*Silvestri, (1934) *Entomologia Applicata*, 1., p. 401, considers that *Bemisia gossypiperda* M. & L. is a synonym of *B. tabaci* Genn. (*Agric. ellenica*, 1889).

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and Trehan [1933]. This insect is generally found feeding on *bhendi* in very small numbers and unlike the jassids and the aphis, it cannot be regarded as a pest.

Experiments with jassids. Populations of jassids were collected from heavily diseased *bhendi* plants in fields in small glass vials, brought to the laboratory and sorted out to separate the males from the females before liberating them on test plants enclosed individually in muslin cages. These insects were allowed to feed on test plants for two to four days, and on completion of the feeding time, were destroyed on the plants by giving a few puffs of calcium cyanide dust into the cages.

The jassids oviposited copiously into the leaf veins. A few days after the nymphs which hatched out of the eggs, were either removed with a sabel hair brush and destroyed or killed on the plants by spraying with fish-oil-rosin-soap.

In transmission tests with *Empoasca devastans* and *Empoasca* sp., 60 healthy *bhendi* seedlings were inoculated between July 18 and 26, 1939, by colonizing 5 to 25 insects on each plant, and the test plants were then kept under observation for over 60 days in the glass-house. None of the plants developed the disease.

Experiments with aphid. Large number of alate and apterous viviparous females and some nymphs of *Aphis gossypii* were collected from heavily diseased *bhendi* plants in nature and liberated on healthy test plants in the glass-house. Two methods were employed for transferring aphids to healthy plants. Firstly, the insects were lifted one by one with a moistened sterile brush and gently deposited on foliage of the test plants. In the case of second method small portions of diseased plants bearing a definite number of aphids were cut out and placed on test plants. The insects gradually migrated to *bhendi* seedlings on which they were allowed to feed for different lengths of time.

In transmission tests with aphids 54 plants were inoculated between 27 July and 11 September, 1939, with 15 to 30 insects on each plant, and were allowed to feed on them for varying periods At the conclusion of the feeding period on test plants, the aphids were destroyed by spraying with nicotine sulphate. Test plants were then removed to another insect proof glass-house and kept under observation for over two months. None of the plants developed the disease.

Experiments with the white-fly. Populations of white-fly adults were collected from diseased *bhendi* plants and transferred to three to four weeks old healthy *bhendi* seedlings enclosed individualy in cellophane or muslin cages. As it was difficult to collect large number of white-flies from *bhendi* plants, collections were made from sun-flower (*Helianthus annuus* L.). These insects were first fed for 24 hours on foliage of diseased *bhendi* plants and then utilised in transmission tests. At the conclusion of the feeding period on test plants the white-flies were destroyed by spraying with fish-oil rosin-soap and the plants were kept under observation for over two months.

When the plants were caged individualy and subjected to the feeding of numerous white-fly adults, the insects oviposited freely on the plants and after a few days, eggs laid on leaves hatched out into nymphs, whose presence could not be detected till a late stage of their development. These nymphs developing into

adults resulted in a general infestation of the glass-house. As no fumigant effectively destroys the egg and the larval stages of the fly, the feeding technique with these insects had to be modified to prevent recurrence of infestation of the glass-house with the adult insects. A method was devised, therefore, to confine them during feeding on a single leaf which could safely be cut off after about a week, and discarded with all the nymphs and pupae before the adults could emerge.

A simple micro-cage for confining white-flies for feeding them on single leaves was devised (Plate IX, fig. 2). This cage does not differ in principle from those described by Storey [1928], Giddings [1939] and Pruthi and Samuel [1939], but it is simpler in construction and easier to manipulate.

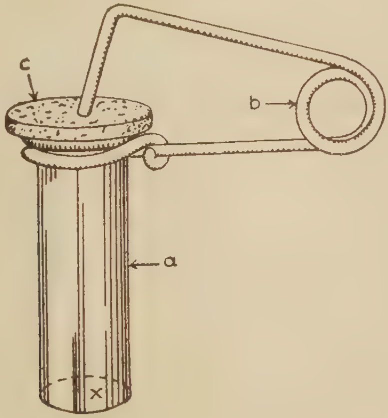

Fig. 1. A microcage for feeding white-flies on leaves of plants for inoculation with the virus.

(*a*) Glass tube.

(*b*) Iron wire spring.

(*c*) A piece of thick cork.

(*x*) The open end of the tube.

The micro-cage consists of a two inch long glass tube Fig. 1, (*a*) open at both ends and of 3/4 inch internal diameter. One end of the tube is made into an inverted rim ground to a smooth surface on a piece of hard stone with emery powder. The rim allows the tube to be held in position by means of a spring clip (*b*) constructed from galvanised iron wire. Between the free end of the spring and the rim of the glass tube a round piece of thick cork (*c*) is inserted and held in position by the tension of the spring. The insects are introduced into the tube from the smooth end (*x*), which is afterwards closed by tying a piece of muslin or *voil* over it (Plate IX, fig. 2), thus completing the micro-cage. For fixing the cage on a leaf, the spring is adjusted to a suitable tension by merely raising or pressing down its free end and the leaf inserted between the cork and the tube. In order to keep

the microcage in a vertical position, it is fastened to a piece of thick galvanised wire pressed into the soil (Plate IX, fig. 2). The whole unit is quite inexpensive and costs about one anna (1/16th of a rupee).

As the white-flies are positively phototropic, the glass tube is ensleeved in a loose tube of black paper to shut out light except from the upper end of the microcage, so that the insects move to the illuminated portion of the leaf and soon settle down for feeding. The results of transmission experiments with the white-fly given in Table II clearly show that the yellow vein-mosaic virus of *bhendi* is readily transmitted by this insect.

TABLE II

Transmission of yellow vein-mosaic virus of bhendi *by* Bemisia tabaci

Date of transfer of white-fly adults to test plants	Feeding period on test plants in days	Number of vectors per plant	Result*
August 23, 1939	5	15	3/4
August 23, 1939	5	20	1/1
September 2, 1939	5	25	5/5
September 9, 1939	1½	20	3/3
September 9, 1939	1½	30	2/2
September 9, 1939	1½	50	2/2
September 16, 1939	1½	20	3/3
September 16, 1939	1½	25	3/3
September 16, 1939	1½	30	2/2

**Numerator*—the number of test plants infected.
Denominator—the number colonized.

Following inoculation with about 20 viruliferous white-flies, four week old *bhendi* seedlings showed the first symptom of disease in about 12 to 18 days during summer and 16 to 24 days during winter months under conditions of temperature, light and humidity prevailing in the glass-houses at Poona.

Stock culture of the white-fly. After demonstration that the white-fly was the vector of yellow vein-mosaic virus, it was necessary to maintain virus free colonies of this insect for experimental purposes. Therefore, a large number of female white-flies were collected from *Halianthus annuus* and tested on *bhendi* plants for their freedom from natural infection with the virus. These insects were then colonised on *Nicotiana tabacum* L., *Solanum malongena* L., and *Gossypium hirsutum* L. growing in pots and kept inside large muslin covered cages (measuring 2½ ft.×

$2\frac{1}{2}$ ft. $\times 2\frac{1}{2}$ ft.) in an insect proof glass-house. Tobacco proved to be a very congenial host for white-flies and is also immune to yellow vein-mosaic virus. The cultures were periodically tested for their freedom from the virus by observing reactions on *bhendi* and hollyhock plants enc'osed in cages containing stock cultures.

Non-transmission of infective power through eggs of white-flies. In order to ascertain if the virus of yellow vein-mosaic was congenitally transmitted through the eggs of its vector, a large number of viruliferous female adults of the white-fly were allowed to feed on healthy *bhendi* plants for 16 hours. The flies were then destroyed by spraying with fish-oil rosin soap. After a few days, the nymphs which hatched out of the eggs laid on leaves were carefully transferred to healthy *bhendi* seedlings upon which they were allowed to feed in some cases for seven days and in others for the whole period of their nymphal and pupal stages. But in none of these cases the test plants became diseased.

In other series of trials viruliferous white-fly female adults were allowed to oviposit on cotton, which is immune to the yellow vein-mosaic virus, and the adults hatching out of the eggs laid on these leaves were transferred to healthy *bhendi* plants. The insects were destroyed by fish-oil rosin soap after they had fed for 24 hours on *bhendi*. In none of these trials was any test plant diseased.

Non-transmission of the virus by dodder. Acquisition of some viruses and their transmission to new hosts by dodder [Bennett, 1940; Johnson, 1941*a* and 1941*b*] has opened up another possibility in the study of plant viruses. Since yellow vein-mosaic virus of *bhendi* is not sap-inoculable and is also not transmitted by the white-fly to some plants very closely related to *bhendi*, it was desired to find out if this virus could be acquired from diseased *bhendi* plants and then transmitted to healthy seedlings by dodder, *Cuscuta reflexa* Roxb., which is a common parasite at Poona on *Durantarepens* L.

For these experiments dodder was first established on diseased *bhendi* plants and when new shoots appeared they were broken off and twined round healthy *bhendi* plants. The dodder established union with the test plants a couple of days after breaking of connection with the diseased *bhendi* plant. The cut end of dodder shoot was kept immersed in a tube of water till it established complete union with the host [Costa, 1944]. Thirty three *bhendi* plants were inoculated in this manner and it was observed that dodder established itself sooner or later on all of them, but in no case the disease was transmitted to any of the test plants.

In another trial, dodder was first established on diseased *bhendi* plants and the new shoots as they grew out were trailed round stems of healthy test plants kept near the diseased plants. In these tests dodder was not separated from the diseased plant at all and in this manner twenty *bhendi* plants were inoculated, but in no case the disease was transmitted to healthy seedlings.

Host range of the virus

The white-fly, *Bemisia tabaci*, is almost a polyphagous insect feeding upon a large number of cultivated plants and weeds, some of which exhibit in nature

symptoms of yellow vein-mosaic or some kind of curl. These plants were therefore tested for their susceptibility to the yellow vein-mosaic virus of *bhendi*.

Since *Hibiscus esculentus* has been reported to be one of the host plants of 'leaf-curl' disease of cotton [Kirkpatrick, 1931], it was considered desirable to test whether Sakallaridis cotton (*Gossypium peruvianum* x *G. barbadense*) was susceptible to *bhendi* yellow vein-mosaic virus. For these tests seed of 'Sakel' cotton was obtained from the Agricultural Research Institute, Wad Medani, Sudan.

All plants for host range determination were raised from seed in pots in the insect proof glass-house and were inoculated with a large number of viruliferous white-flies confined in micro-cages. All the species of plants inoculated in this manner and the results obtained are given in Table III.

TABLE III

Results of inoculation of different species of plants with bhendi *yellow vein-mosaic virus by means of* Bemisia tabaci

Species of plants	Number of plants inoculated	Number of plants infected
Sakellaridis cotton	12	0
Hibiscus esculentus var. *American Long*	8	8
H. esculentus var. *American Dwarf*	5	5
H. abelmoschus L.	17	15
H. sabdariffa L.	18	0
H. cannabinus L.	18	0
H. manihot L.	6	0
H. moscheutos L.	10	5
H. tetraphyllus Roxb.	10	10
**H. furcatus* Willd.	6	0
**Althaea rosea* Cav.	10	8
**Sida rhombifolia* L.	12	0
Abutilon indicum Sweet	4	0
**Vernonia anthelmintica* Willd.	6	0
**Eclipta alba* H.	6	0
**Ageratum conyzoides* L.	6	0

* Plants in nature suffer from viruses of yellow vein-mosaic type, which apparently are different viruses.

TABLE III.—*contd.*

Results of inoculation of different species of plants with bhendi *yellow vein-mosaic virus by means of* Bemisia tebaci

Species of plants	Number of plants inoculated	Number of plants infected
Sonchus sp.	6	0
Zinnia elegans Jacq.	8	0
Lycopersicum esculentum Mill.	12	0
Capsicum frutescens L.	12	0
Solanum melongena L.	6	0
S nigrum L.	8	0
Niotiana tabacum L.	8	0
N. glutinosa L.	8	0
Petunia hybrida Vilm.	6	0
Datura alba Nees	8	0
Vigna sinensis Endl.	11	0
Dolichos lablab L.	6	0
Cassia tora L.	5	0
Phaseolus vulgaris L.	8	0
Trifolium pratense L.	6	0
Medicago sativa L.	6	0
Corchorus trilocularis L.	6	0
Euphorbia geniculata Ort.	8	0

The host range of the virus is limited only to a few species of plants in the family Malvaceae. Sakallaridis cotton is definitely immune to the yellow vein-mosaic virus, which was also not transmitted by white-flies to *Hibiscus cannabinus* and *H. sabdariffa*.

Hibiscus tetraphyllus is the only weed naturally infected with the virus of yellow vein-mosaic of *bhendi* in the Bombay Province. The symptoms of disease in this species are similar to those in *bhendi* (Plate VIII, fig. 4), and the virus when transmitted from *H. tetraphyllus* to *bhendi* by means of white flies induces in the latter charac. teristic symptoms of yellow vein-mosaic.

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Young plants of *Hibiscus abelmoschus*, *H. moscheutos* and *H. tetrephyllus* show the first symptom of disease in the form of clearing of small veins in about twenty days after inoculation. The chlorosis of veins soon follows and the plants develop typical yellow vein-mosaic pattern. In *Althaea rosea* the symptoms of disease usually appear in about thirty days in the form of faint vein clearing of young leaves followed closely by swelling of veins at several points on the under sides of leaves. The vein swelling gradually extends to almost all veins (Plate IX, fig. 4) which become thickened and gnarled as the leaf grows in age. Every leaf shows up faint vein clearing at some stage of its growth, but it usually outgrows this symptom, and the typical yellow vein symptoms like those in *bhendi* are never developed. Foliar enations or out-growths are also not formed. The thickened veins are deep green in colour and appear opaque when seen against light. All growth subsequent to infection is dwarfed and the leaves cluster at the top of diseased plants on account of extreme reduction in size of internodes and also of leaf petioles (Plate IX, fig. 3). The virus is readily acquired by white flies from these host plants and transmitted back to the respective hosts and also to *Hibiscus esculentus*.

Transmission of the virus by tissue union only. During host range determination of the virus it was observed that the white-fly is unable to transmit the virus to several plants (Table III). Experiments were done to see if the virus could be transmitted to some of the Malvaceous plants by graft inoculation. About thirty day old healthy seedlings of some such plants were cleft-grafted with scions of diseased *bhendi* and it was observed that the virus was readily transmitted to *Hibiscus sabdariffa* and *H. cannabinus*, but not to *H. furcatus* or *Abutilon indicum* (Table IV).

TABLE IV

Transmission of the virus by graft inoculation

Date of grafting	Name of Plant	Number of plants grafted	Number of successful grafts	Number of plants diseased	Date when disease appeared
April 29, 1946	*Hibiscus cannabinus*	6	3	3	May 15, 1946
May 2, 1946	*H. sabdariffa*	6	5	5	May 18, 1946
May 9, 1946	*H. cannabinus*	3	3	3	May 22, 1946
July 4, 1946	*Abutilgn indicum*	3	3	0	..
July 5, 1946	*H. sabdariffa*	6	6	6	July 20, 1946
July 5, 1946	*H. cannabinus*	6	5	5	July 21, 1946
July 16, 1946	*H. tetraphyllus*	3	3	3	August 8, 1946
July 16, 1946	*H. abelmoschus*	4	4	4	August 8, 1946
April 7, 1947	*H. furcatus*	6	6	0	..

The first symptoms of disease in the grafted plants appeared in about 13 to 23 days, though the union between the stock and the scion was invariably established in much shorter time. The disease was transmitted to all plants in which union

between stock and scion was successful, and in most cases the grafted scion grow well on the stock (Plate X, fig. 1).

The symptoms of disease in *H. sabdariffa* and *H. cannabinus* were profuse vein-swellings of almost all veins on the under sides of leaves and moderate downward curling of leaf margins (Plate VIII, fig. 5 : Plate IX, fig. 5). Diseased plants remain dwarfed and the leaves are considerably reduced in size. It is interesting to note that the symptoms of disease induced in *H. tetraphyllus* and *H. abelmoschus* on graft inoculation were of the typical yellow vein-mosaic pattern accompanied with vein-swellings.

Diseased plants of *H. cannabinus* and *H. sabdariffa* were indexed on healthy seedlings of the same species and also on *bhendi* by means of the vector in order to ascertain if the white-fly is able to acquire the virus from these plants and transmit it back to them as well as to *bhendi*. The results, given in Table V clearly show that the insects are able to acquire the virus on feeding upon diseased leaves of these plants (as shown by their ability to infect *bhendi*), but cannot transmit it either to *H. cannabinus* or to *H. sabdariffa*.

TABLE V

Ability of the white fly to acquire the virus from leaves of diseased Hibiscus cannabinus *and* H. sabdariffa

Trial	Infection feeding on	Test plant	Number of plants inoculated	Number of plants diseased
A	*H. cannabinus*	*H. esculentus*	4	4
	H. sabdariffa	do.	4	4
B	*H. cannabinus*	*H. cannabinus*	1	0
	H. sabdariffa	*H. sabdariffa*	4	9
C	*H. cannabinus*	*H. cannabinus*	7	0
Control	*H. esculentus*	*H. cannabinus*	5	0
	do.	*H. sabdariffa*	8	0

A few plants, specially of *H. sabdariffa*, showed signs of recovery from the diseased condition. In such plants vein-swellings and rugosity of leaves were greatly reduced. A few others showed partial recovery. In these the new developing leaves looked almost normal with a few scattered vein-swellings. Most of these plants later got a sudden set-back and produced severely diseased leaves with the usual profuse vein-swellings, curling of margins, rugosity and reduction in size. One plant of *H. sabdariffa* produced perfectly healthy looking shoots with normal leaves without any sign of thickened veins (Plate X, fig. 2), although there were two diseased shoots still persisting at its base.

R

Control

The economic importance of the disease cannot be denied as it reduces the yield considerably and causes much loss to the grower. The disease spreads rapidly from one infected field to another, as the affected fields act as foci of infection not only for the neighbouring plots but also for the entire area under *bhendi*.

The only redeeming feature about the disease is its restricted host range. *Hibiscus tetraphyllus*, the weed host of the virus, grows during monsoon and early part of winter. Therefore, continuous cultivation of *bhendi* should not be encouraged for the obvious reason that the old plantation remains a main source of infection for new *bhendi* crop wherever it is sown.

In view of the above observations the following measures for controlling the disease are suggested :

(i) eradication of *Hibiscus tetraphyllus*, the wild host of the virus,

(ii) observing a close season of at least two months during summer between two successive crops,

(iii) roguing diseased *bhendi* plants at the earliest stage of their infection,

(iv) spraying the crop once in three weeks with fish oil rosin soap with a powerful sprayer to keep in check the white-fly population, and

(v) keeping the fields clean of weeds, as many of these act as food plants of the white-fly and help in its multiplication.

Discussion

Owen [1946] described a mosaic disease of *Hibiscus esculentus*, L. in Trinidad and believed it to be different than the yellow vein mosaic of *bhendi* [Uppal *et al.* 1940]. In addition, *H. esculentus* responds to experimental inoculation with the tobacco streak virus [Fulton, 1948] and also with the 'leaf-curl' disease of cotton in Sudan [Kirkpatrick, 1931]. It has also been shown by Kirkpatrick [1931] that it is difficult to transfer the 'leaf-curl' virus back again to 'Sakel' or Watt's long staple (American) cottons from 'Bamia', *H. esculentus*. The virus could easily be transmitted to *H. cannabinus* from 'Bamia' by means of the vector. Although the vector of both the 'leaf-curl' of cotton and the *bhendi* yellow vein-mosaic viruses is the same insect, yet the two viruses are quite distinct from each other because of the primary reason that the latter is not at all infectious to Sakellaridis cotton. Other point of distinction being the inability of the white-fly to transfer the yellow vein-mosaic virus from *bhendi* to *H. cannabinus* and *H. sabdariffa*, the important host plants of cotton 'leaf-curl' virus. Moreover, the symptoms of disease in *H. esculentus* as induced by the cotton 'leaf-curl' virus are entirely different from those produced in it by the yellow vein-mosaic virus. There is, however, one similarity between the two viruses that both of them have a common host in *Althaea rosea*, and there seems to be some similarity in the symptoms expression of the two viruses in this host plant.

Another notable feature of the virus is that it can be readily transmitted to *Hibiscus cannabinus* and *H. sabdariffa* by graft inoculation with diseased *bhendi*. The white-fly can pick up the virus from these plants but is unable to transfer it back to them, although it can readily infect *bhendi*. These observations indicate that the virus is infectious to *H. cannabinus* and *H. sabdariffa* but the vector is unable to communicate the virus to these plants.

Cases of partial recovery from diseased condition in *H. cannabinus* and *H. sabdariffa* were not uncommon, but these plants came down again with a severe attack of the disease. Only one plant of *H. sabdariffa* showed complete and lasting recovery. Similar cases of partial and complete recovery from 'leaf-curl' disease in 'Sakel' cotton were also noticed by Kirkpatrick [1931].

Proposed name and description of the virus

Ochrovena hibiscae Capoor and Varma *gen. nov.* sp. *nov.* is proposed to be the Latin name of the yellow vein-mosaic virus according to the binomial system of nomenclature by Holmes [1939-1948], and as emended and consolidated into a more systematic classification by McKinney [1944]. This genus has been named after two Latin words meaning 'yellow' and 'vein', and is placed in the family Marmoraceae because of the typical mosaic pattern induced by the virus in *Hibiscus esculentus*. According to Smith's [1937] classification the virus is designated as *Hibiscus* virus 1.

Common name—Bhendi yellow vein-mosaic virus.

Description. In *Hibiscus esculentus*, *H. tetraphyllus* and *H. abelmoschus* the virus induces vein-chlorosis, and vein-swellings as well. In *Althaea rosea* it induces only vein-swellings of all the veins and leaf crinkling. In nature the virus is transmitted by the white fly, *Bemisia tabaci*, Genn. It is not trasmitted by inoculation with expressed juice or through seed. The virus is transmitted to *Hibiscus cannabinus* and *H. sabdariffa* by tissue union only. It is neither transmitted by dodder, *Cuscuta reflexa*, nor does it pass through the egg stage of the vector.

Summary

The symptoms of disease, which are described, consist of clearing of vein-lets followed by chlorosis of veins, vein-swellings, slight downward curling of leaf margins and twisting of petioles, and general dwarfing and retardation of growth.

The virus is neither sap-transmissible nor transmitted by seed or through the parasitic activity of dodder, *Cuscuta reflexa*. It is, however, readily transmitted by grafting, and also by the Aleyrodidae, *Bemisia tabaci*, but not by *Empoasca devastans*, *Empoasca* sp. or *Aphis gossypii*.

There is no congenital transmission of the virus to the offsprings of viruliferous white-flies through eggs.

The host range of the virus is limited to the family Malvaceae. In addition to *Hibiscus esculentus*, *H. abelmoschus*, *H. moscheutos*, *H. tetraphyllus* and *Althaea rosea* also respond to infection with the virus. *Hibiscus tetraphyllus* is a weed commonly growing about, and which harbours in nature the virus of yellow vein-mosaic of *bhendi*.

Hibiscus cannabinus and *H. sabdariffa* could be infected with the virus only by tissue union. The vector was unable to transmit the virus to these plants, but readily secured it after feeding on diseased leaves of *H. cannabinus* or *H. sabdariffa* and successfully transmitted it to *H. esculentus*.

Cases showing partial recovery from the diseased condition were common in *H. cannabinus* and *H. sabdariffa*. Only one plant of *H. sabdariffa* showed complete recovery.

Suggestions for controlling the disease have been made.

Ochrovena hibiscae Capoor and Varma *gen. nov.* sp. *nov.* is proposed to be the Latin name of the virus according to the classification by Holmes, and *Hibiscus* virus 1 according to that by Smith.

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LOSS IN FIREWOOD BY DRYING DURING STORAGE

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(Received for publication on 21 October 1948)

(With four text-figures)

IT is often required by commercial firms dealing in firewood or industrial concerns storing firewood and manufacturing charcoal or Government and private institutions or organizations storing firewood for various purposes, to know with fair approximation the probable loss in weight of common types of firewood, available in the locality concerned, due to storage. In fact, such an information was required in the Burma Refugee Camp where at one time about 25,000 md. of firewood were required every month and some quantity had always to be stored for all emergencies to meet dislocation in supply.

This loss in weight by drying in a given time would necessarily depend on the following:

(1) Species of the firewood.

(2) Maturity of the wood.

(3) Initial moisture content while being stored.

(4) Season.

(5) Humidity and temperature of the place at the time.

(6) Shape, size and nature of the pieces, i.e., whether whole logs, thin twigs and branches or split firewood and the dimension of the billets, viz. length, thickness, etc.

(7) Nature of stacking.

(8) Whether kept exposed or kept under shade, etc.

Any accurate determination of the nature of the drying must take into account all these factors. But such accuracy is hardly necessary as at the time of actual storage of the firewood none of these conditions are likely to be controlled in ordinary transactions. What is necessary is to find out approximately the extent of loss due to drying that may be expected in ordinary practical circumstances. But there is very little information on record on this point.

S

Earlier investigations

Rehman at Dehra Dun found the loss in split firewood of *Shorea robusta* (*sal*) from 24·7 per cent to 29·7 per cent according to season. His work in this direction has been also referred to inside. In the experiment started in December, the air dry condition was reached in 28 weeks. It may be noted here that Dehra Dun often has a second monsoon in December and is different from Bengal in this respect. In the experiment started in May, out of the total loss of 24·7 per cent as much as 20 per cent occurred in 11 weeks alone and the rest gradually in 45 weeks more.

Rehman also carried on investigation with *Eugenia jambolona* (*jaman*) and *Machilus duthiei* (*kaula*), starting from November and the losses found were 45·8 per cent and 48·3 per cent respectively. These appear to be similar to the losses in the case of *mango* and *semul* in the Sabirnagar experiment. It took 33 weeks to attain the air dry condition for *jaman* and *kaula* at Dehra Dun.

Narayan Singh [1935] found *kosh* (*Alnus* sp.) firewood stacked in March to lose 33 per cent to 37 per cent of the weight in the first three months and additional 6 per cent during the next six months.

Brahmawar is reported to have found *banj* (*Quercus* sp.) and *burans* (*Rhodden-dron* sp.) to lose 10 per cent to 11 per cent in the open in the forest. When however, protected under shade from rains, he found *banj* to lose 33 per cent and *burans* 60 per cent in 10½ months.

Experimental

With a view to find out the extent of the loss in storage of the common and typical varieties of ordinary country firewood, experiments were carried on, in the Burma Refugee Camp with firewood of mango, *semul* and *banian*, both in the open air and under shade, once during the rains, and again during the dry season, when the humidity is low and drying takes place quickly.

Firewood was brought from the adjacent places conveniently as the Camp is situated in the interior of a rural place, and it was cross-cut and split as quickly as possible after which the observations began. The length of a billet was 3 ft., and diameter 6 in. approximately. Fifty maunds were taken for each experiment and stacked in cubical dumps, one set in the open and another set in the shade, and each stack was reweighed periodically, and the dates and weights were noted till no further reduction in weight was recorded.

Tables I, II, III, and IV below give the results of the experiment :

A. *During rains*

TABLE I

Loss in weight by drying (In open air)

Date	Number of weeks	*Mangifera indica* (mango)			*Bombax malabaricum* (*semul*)			*Ficus bengalensis* (banian)		
		Weight (md.)	Loss (per cent)	Extra moisture* (per cent)	Weight (md.)	Loss (per cent)	Extra moisture (per cent)	Weight (md.)	Loss (per cent)	Extra moisutre (per cent)
30-6-46	..	50	0	78·6	50	0	127·3	50	0	47·1
3-8-46	5	46	8	64·3	44	12	100·0	48	4	41·2
2-9-46	9	43	14	53·6	38	24	72·7	44	12	29·4
3-10-46	13½	40	20	42·8	32	36	45·5	42	16	23·5
4-11-46	18	36	28	28·6	30	40	36·4	38	24	11·8
3-12-46	22	30	40	7·2	25	50	13·6	34	32	0
5-1-47	27	28	44	0	22	56	0	34	32	0
9-1-47	29	28	44	0	22	56	0	34	32	0

* Exrta moisture present $\frac{\text{current weight—air dry weight} \times 100}{\text{air dry weight}}$

TABLE II

Loss in weight by drying

(under shade)

Date	Number of weeks	Mango			*Semul*			Banion		
		Weight (md.)	Loss (per cent)	Extra moisture (per cent)	Weight (md.)	Loss (per cent)	Extra moisture (per cent)	Weight (md.)	Loss (per cent)	Extra moisture (per cent)
2-9-46	0	50	..	92·3	50	..	100·0	50	..	78·6
4-10-46	4½	46	8	76·9	40	20	60·0	45	10	60·6
5-11-46	9	36	28	38·6	30	40	20·0	41	18	46·4
5-12-46	13	30	40	15·3	26	48	4·0	34	32	21·4
5-1-47	18	..	..	..	25	50	0	28	44	0
19-1-47	20	26	48	0	25	50	0	28	44	0

B. *During winter, i.e., dry season*

TABLE III

Loss in weight by drying

(in open air)

Date	Number of weeks	Mango			*Semul*		
		Weight (md.)	Loss (per cent)	Extra moisture (per cent)	Weight (md.)	Loss (per cent)	Extra moisture (per cent)
17-11-46	..	50	..	66·6	50	..	108·2
16-12-46	4	41	18	36·6	37	26	54·2
19-1-47	9	35	30	16·6	34	32	41·7
17-2-47	13	33	34	10·0	28	44	16·7
12-3-47	17	32	36	6·6	26	48	8·8
10-4-47	21	30	40	0	24	52	0
27-4-47	23	30	40	0	24	52	0

TABLE IV

Loss in weight by drying

(under shade)

Date	Number of weeks	Mango			*Semul*		
		Weight (md.)	Loss (per cent)	Extra moisture (per cent)	Weight (md.)	Loss (per cent)	Extra moisture (per cent)
17-11-46	..	50	..	56·2	50	..	100·0
16-12-46	4	44	12	37·5	40	20	60·0
19-1-47	9	41	18	28·1	35	30	40·0
17-2-47	13	37·5	25	17·2	30	40	20·0
12-3-47	17	35	30	9·4	28	44	12·0
10-4-47	21	32	36	0	25	50	0
27-4-47	23	32	36	0	25	50	0

For easy comparative estimation of the loss of a particular firewood in the open and under shade and in the two different seasons and also of the different rate of loss in the different species, the results are shown graphically below in Figs. 1-4.

Discussion

In about 22 weeks, i.e., little over five months, almost complete drying takes place during rains in the open. During the dry season much of the drying is completed after 15 weeks only.

During the rains, *Bombax malabaricum* (*semul*) lost 56 per cent on complete air drying in less than 27 weeks, *Mangifera indica* (mango) 44 per cent and *Ficus bengalensis* (*banian*) 32 per cent during the same period. These are all in the open, in the shade during rains, *semul* dried 50 per cent, mango 48 per cent and *banian* 44 per cent in 20 weeks.

During the winter, *semul* lost 52 per cent and mango 40 per cent in less than 21 weeks in the open and became completely air dry. The corresponding losses under the shade were 50 per cent and 36 per cent respectively.

During rains, the rate of drying under the shade is higher than that in the open while during the dry season, the rate of drying in the open is higher than in the shade.

But it appears from the results of drying (most prominently brought out in the data obtained for *semul*) that ultimately the firewood either in the open or in the shade whether during rainy season or during winter, tends to the same state of drying. This is borne out by the results obtained by Rehman [1941], viz., that firewood after complete air drying retains only 10 per cent to 14 per cent moisture content ; the final moisture is, therefore, fixed irrespective of the firewood being kept in the open or under shade or during rains or winter. These modes of treatment only influence the rate of drying or loss before attaining the complete air dry stage.

But from the curves for mango or *banian*, it may appear that each of them ended with different stages of drying, i.e. higher or lesser percentage losses in weight during the rains and the winter. This apparent difference was primarily due to the different initial moisture contents when the experiments were started. This may be seen from the column in each table showing extra moisture in per cent.

Thus, both the losses in mango firewood during the dry season in the open air and under shade, viz. 40 per cent and 36 per cent were less than the corresponding losses during the rains, viz. 44 per cent and 48 per cent respectively, although it might be expected that the loss during the dry season should have been more than that during the rains. The loss in the dry season appears to be less as during the dry season, the extra moisture present was less as will be seen from Tables, I, II, III, and IV. Some loss in moisture content already took place even during the short period taken to fell the tree, cross cut and split the firewood and the experiment started with lower moisture content.

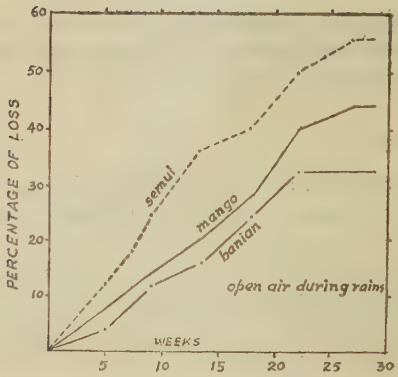

Fig. 1. Loss of firewood by drying

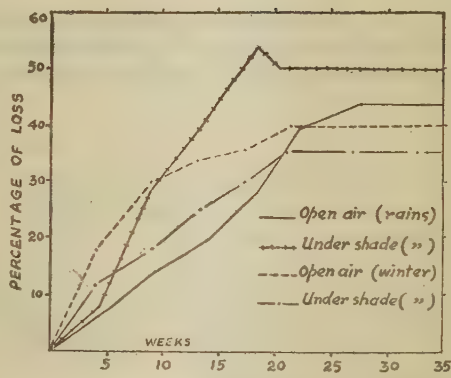

Fig. 2. Loss of mango firewood by drying

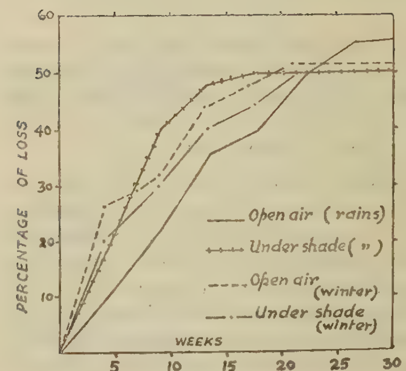

Fig. 3. Loss of *semul* firewood by drying

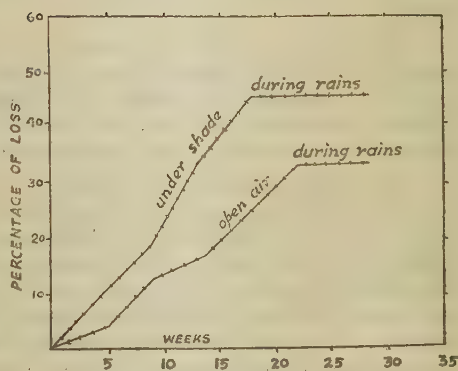

Fig. 4. Loss of *banian* firewood by drying

Rehman also found the same thing in the two experiments performed by him at Dehra Dun with *sal* firewood. In one experiment the loss was 39·7 per cent in split firewood, and in the other, only 24·7 per cent. In the first experiment the initial moisture content was 85·8 per cent and in the second, 50·5 per cent due to the same reason as stated above.

Thus, moisture content of firewood at the time of stacking is less in dry season from say November to April than during the rest of the year specially during rains. Loss in firewood stacked in winter, is, therefore, less than that during rains.

Loss by drying in *semul* is the heaviest of the three while that in *banian* is the lowest, mango lies in between.

Once completely air-dried, firewood gains in weight very little even when exposed to rains.

Due to long storage under the sun and in rains even after normal drying rotting takes place and further heavy loss occurs when the wood loses much of its fuel value. One maund of firewood after such rotting was found to weigh only 11 sr. after 18 months.

It appears that measuring ordinary country firewood by weight is misleading and not satisfactory specially when it has to be dealt with in great bulk. When dealing with large quantity of firewood, measurement by volume is a better method. In many countries, firewood is sold by volume. In the Burma Refugee Camp, firewood was stacked (for reserve) in uniform stacks of 1,000 md. each and on an average the dimensions were 24·25 ft. in length, 22·5 ft. in breadth and 5·4 ft. in height for mixed variety, viz. mango, *semul*, *banian* and a few other small and unimportant varieties. The volume per 1000 md. is, thus, 2946 cu.ft. or say, 3000 cu.ft. The volume at the time of stacking and after six or seven months was the same, although the weight after that period had become almost half.

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CONTROL OF FLY BREEDING IN COMPOSTING

1. EFFECT OF CHEMICALS ON FLY BREEDING

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THE control of fly breeding in any system of composting, particularly from town wastes, is of utmost importance from public health considerations, as on this depends almost entirely the successful adoption of the method by the local bodies and in return of production of a valuable manure, which is of immediate value in improving soil fertility and increasing food production. Acharya and Rao [1945] have distinguished between ' internal ' and ' external ' types of fly breeding, i.e., fly maggots which are already present in the night-soil and refuse masses at the time of trenching and which ultimately develop into flies, from those which are caused extraneously by the flies sitting on the exposed refuse at the compost depot. Fortunately, in most of the methods of trenching or pitting, if the depot is clean the chances of ' external ' fly breeding are little, since the trenches are ultimately covered with earth. But it is the ' internal ' type of fly breeding against which the compost system has to prove effective.

The most recent method of composting, being followed at present, on all-India basis, is the Bangalore process of composting in which fly nuisance is greatly minimised due to development of a high temperature during composting. Experience has shown that while this is perfectly true for summer and dry winter months, when the temperature in the compost trenches rises up to 60°C. or higher, dead maggots having been actually observed in a number of cases, during rainy season, however, fly breeding is not completely controlled as no sooner does the temperature tend to rise than it is lowered by occasional showers. This intermittent rise and fall of temperature does not prove lethal for fly maggots. Recourse to some external method for controlling fly breeding during this period is thus of obvious importance.

Fly breeding is conditioned by a number of factors ; e.g., (1) system of collection, there being less of fly breeding in the dry system of collection than in the wet one, where night-soil is mixed with urine and ablution water, (2) presence of rapidly decomposing soft material, and (3) high humidity accompanied with low temperature as during rains. On the same basis there may be distinguished three seasons in the year in tropics when fly breeding is at its maximum. These are : (a) February to March when winter shower is followed by rise in temperature, favourable to fly growth, (b) end of June to first week of July when the first rainy season showers introduce humidity in the atmosphere and (c) during rainy season when there is constantly high humidity and the temperature is not too high.

Several methods have been recommended from time to time for controlling fly breeding, e.g., chemical, physical, biological, thermal and electrical methods [for details see Acharya and Rao, 1945], but few of them seem to be entirely satisfactory for routine operation, mainly due to variations in local conditions. Acharya and Rao's [1945] tarred cloth method, in a preliminary trial here, did not prove to be very effective. The young flies were found to collect under the cloth cover and stay in that state without being asphyxiated for as much as a week. In that arrested state they may even be responsible for further breeding. Besides this, there was always a tendency amongst workers to finish with the trench once for all and never again return to it for another operation as is required in the tarred cloth method. Joshi and Dnyansagar [1947] recommend application of $1\frac{1}{2}$ pounds of crude oil or 12 pounds of bleaching powder per 100 square feet, in two doses, the first one on the day of filling of refuse and the second one on 8th day, as effective means of controlling fly breeding. This also necessitates repitition of treatments. The need for some suitable treatment which would be finished in one operation and the effect of which would last for several days, was thus keenly felt. A number of chemical substances with known insecticidal properties, e.g., lime, bleaching powder, DDT, wood ash and gammexane were consequently compared, the results of which are described in the present communication.

Experimental

The trials were conducted in August, 1947, during rainy season when fly emergence is generally at its maximum, so that the results can be applicable in less favourable periods also for fly growth. Kerosine oil tins, cut length-wise to make 14 in. $\times$ 9·25 in. $\times$ 9·25 in. containers, were used for the purpose. The following treatments were compared in duplicate :

(*a*) One inch thick earth-lime cover (10 : 1) : 1,500 grams of earth mixed with 150 grams of lime and spread over *katchra* layer ;

(*b*) Half inch thick lime cover : pure lime spread over *katchra* layer : no earth cover being put after that ;

(*c*) One inch thick earth-borax cover : (10 : 1) : 1,500 grams of earth mixed with 150 grams of borax and spread over *katchra* layer ;

(*d*) Half-inch thick borax cover : pure borax spread over *katchra* layer : no earth cover being put after that ;

(*e*) One inch thick earth bleaching powder cover : (20 : 1) : 1,500 grams of earth mixed with 75 grams of bleaching powder and spread over *katchra* layer ;

(*f*) Twenty per cent bleaching powder solution spread over *katchra* layer at the rate of 250 c.c. per tin and finally covered with 2 in. loose earth os in compost technique ;

(*g*) One inch thick 2 per cent earth-DDT cover : 1,500 grams of earth mixed with 30 grams of DDT and spread over *katchra* layer ;

(*h*) One inch thick 5 per cent earth-DDT cover : 1,500 grams of earth mixed with 75 grams of DDT and spread over *katchra* layer ;

(*i*) One inch thick 0·1 per cent earth-gammexane cover : 1,500 grams of earth mixed with 1·5 grams of gammexane (as recommended by Imperial Chemical Industries) and spread over *katchra* layer ;

(*j*) One inch thick 0·2 per cent earth-gammexane cover : 1,500 grams of earth mixed with three grams of gammexane and spread over *katchra* layer ;

(*k*) One inch wood ash cover : spread over *katchra* layer, no earth cover being put after that ;

(*l*) Control : two inches cover of earth alone.

The ideal method for using DDT, however, is in the form of solution in kerosene oil or in watery emulsion. In the case of emulsion or oily solution, it is important to use a coarse spray so that, after evaporation, the active principle remains behind as a residual contacting insecticide. This needs a special equipment. DDT is also used in the form of dust, by mixing with some inert material, such as kaolin-talc (hydrous magnesium silicate) or pyrophyllite (hydrous aluminium silicate) or waste flour. This does not require any special equipment but can be done by hand. Similarly gammexane can also be used in the form of dust after diluting it with some locally available, finely divided, inert diluent. It is easily decomposed by alkali and is therefore not advisable to mix with lime or other alkaline materials. But considering the practical difficulties in obtaining necessary equipment for preparing and spraying these insecticides in solution or in emulsion on a routine basis and its subsequent handling by the sweepers, the large quantity that has to be used every time for the purpose and the consequent additional charge on the economics of compost making that would naturally result from it, as also the non-availability of inert materials in every area, it was considered desirable to try mixing DDT and gammexane with locally available earth, on the compost grounds. The earth used in the present experiment was sand, had *p*H 8·2 and contained 1·31 per cent of free calcium carbonate (as tested by carbon dioxide evolution method) and 0·88 per cent N/2 acetic acid soluble calcium oxide. Although the material taken was not inert it may perhaps be taken at the same time not to contain free alkali so as to effect appreciably the decomposition of DDT or gammexane. The mixture was prepared as intimately as possible by hand.

The tins were filled with three inch *katchra* at the bottom and then with one inch night-soil, over which was spread an inoculum containing 1,000 maggots. A three inch layer of *katchra* was subsequently put on top and the treatments (a to l)

completed. Blank tests were also included by filling two tins as above but without any external inoculum. The fly emergence from these indicated the number of fly maggots originally present in the refuse and night-soil mass in the tins. It was found that on an average 1,060 flies emerged from each such tin, with only a slight variation of nearly two per cent between them. A total of thus internally present and externally added inoculum provided the maximum number (2060) of fly emergence expected from each experimental tin and the actual emergence has been expressed as a percentage of this.

The inoculum was obtained from the night-soil reaching the compost ground, by picking with the help of a forceps and a brush. This method was advantageous as the maggots were picked from their natural habitat and being obtained on the same date and from the same sample may be taken to have been nearly in the same stage of development. Raising of inoculum in cow dung-urine mixture was also tried as suggested by Acharya and Rao [1945] but it proved slow and tedious. It was, however, later found during the course of the observations during the present experiment that the inoculum obtained from night-soil contained a mixed population of house flies and blue bottles.

After the tins were filled, they were fitted with a mosquito netting mounted on four pegs on the four corners, the flaps of the netting being tied round the edge of the tins. A small opening, to be closed at will, was left on the top of the net through which fly emergence was counted every day between 2·00 p.m. and 4·00 p.m. The tins were protected under a shed from direct rainfall but on three occasions during the course of the experimentation some water did drop on them through a small leakage in the roof. This may have prevented rise of temperature to some extent.

Results

The results (average of two) are given in Table I. It would be seen that the fly emergence started from even the third day after filling and reached a maximum between seventh and tenth day. Acharya and Rao [1945] and Joshi and Dnyansagar [1947] observed that fly emergence in their experiments started on the 8th or 9th day after filling and reached a peak on 14th to 15th day and on the same basis recommend application of treatments after nearly a week after filling the trench. In our experiment, however, fly emergence ceased completely on the 15th day. The difference may be due to season and local conditions. But as the night-soil reaching the compost ground is already infested with a large number of maggots and which are in different stages of development and which start emerging out even on the second or third day of filling, it would appear to be of little benefit to wait for a week before application of treatments by which time most of the maggots would have developed into flies and escaped out. A treatment which should be effective right from the first day and the effect of which would last for sometime is thus greatly warranted.

Table I

Effect of chemicals on fly emergence in compost mass

Serial number	Treatments	Days after filling														Percentage emergence
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	
1	One inch 10 per cent earth-lime cover	4	5	3	24	98	261	178	478	137	43	9	9	3	0	1,242	60·3
2	Half inch lime cover	3	2	2	21	122	145	365	253	462	64	16	13	5	2	1,475	71·6
3	One inch 10 per cent earth-borax cover	1	1	1	3	0	0	0	0	0	1	0	0	0	0	7	0·34
4	Half inch borax cover	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0·0
5	One inch 5 per cent earth-bleaching powder cover	3	3	0	2	10	109	112	350	180	26	22	12	2	2	853	40·43
6	Twenty per cent bleaching powder spray	4	1	0	15	52	178	415	340	140	9	10	2	0	0	1,166	56·6
7	One inch 2 per cent earth-DDT cover	0	0	5	26	70	115	130	38	35	37	20	3	2	0	481	23·3
8	One inch 5 per cent earth-DDT cover	1	5	7	45	125	172	52	6	2	0	0	0	0	0	415	20·1
9	One inch 0·1 per cent earth-gammexane cover	0	3	12	9	29	30	146	14	2	1	0	0	0	0	296	14·6
10	One inch 0·2 per cent earth-gammexane cover	0	0	1	2	17	112	143	58	21	0	2	0	0	0	356	17·3
11	One inch wood ash cover	3	4	0	18	45	200	8	8	6	2	1	0	0	0	295	14·6
12	Two inch earth cover	0	0	2	3	10	150	165	100	15	6	1	0	6	0	458	21·7

A statistical analysis of the effects of various treatments is given in summary of results in Table II in which the dates have been expressed as their logarithms where X represents the number of flies emerged. The figures are arranged in an ascending order.

TABLE II

Summary of results

Serial number	Treatments	Mean log (1+X)	Percentage of general mean
1	Half inch borax cover	0·5493	10·0663
2	One inch 10 per cent earth-borax cover	1·7918	32·8361
3	One inch 0·2 per cent earth-gammexane cover	5·6688	103·8851
4	One inch wood ash cover	5·6904	104·2809
5	One inch 0·1 per cent earth-gammexane cover	5·7854	106·0219
6	One inch 5 per cent earth-DDT cover	6·0279	110·4658
7	Two inch earth cover	6·1291	112·3204
8	One inch 2 per cent earth-DDT cover	6·1683	113·0388
9	One inch 5 per cent earth-bleaching powder cover	6·8065	124·7343
10	Twenty per cent bleaching powder spray	6·9959	128·2052
11	One inch 10 per cent earth-lime cover	7·1096	130·2888
12	Half inch lime cover	7·2123	132·1709
	General mean	5·4568	100·0000
	Critical difference—		
	at 5 per cent	1·1341	..
	at 1 per cent	1·6130	..
	at 0·1 per cent	2·3348	..

It will be seen from Table II that borax significantly stands out as the most effective treatment in destruction of flies. It is interesting that in all the four tins with borax fly emergence was practically negligible as compared to other treatments. This appears to be quite a promising method for control of fly breeding. Next in order came gammexane, wood ash, DDT and earth cover. Although the differences within these treatments are not statistically significant, it will be seen that gammexane and wood ash are comparatively more effective. Even 0·1 per cent mixture of

gammexane with earth stopped fly breeding to the extent of 85 per cent (Table I). The insecticidal properties of wood ash are not precisely known but the results in the present experiment indicate that this may be used quite successfully for controlling fly breeding which also perhaps finds confirmation in the common practice of sweepers of covering night-soil with ash. It would be useful to investigate this point further under widely different sets of conditions, as ash, if found successful, would undoubtedly prove a cheap and ready at hand material for covering the trenches.

Bleaching powder and lime in any combination proved ineffective in destruction of fly maggots. Application of lime is almost a universal recommendation with sanitary authorities for controlling fly breeding but in the light of the results obtained in the present experiment this view can hardly be tenable. In fact, when the lime treatment is compared with the two inch earth-cover treatment which is recommended in composting technique and which is taken as control in the present experiment, it is found that even the earth-cover treatment is significantly better than lime. It is interesting that in a preliminary trial at Jhansi (United Provinces) in 1943-44, Dr S. D. Misra, the Municipal Medical Officer of Health at that time also found that lime cover did not stop fly breeding (private communication). His trials were conducted in 4 ft. $\times$ 4 ft. $\times$ 4 ft. trenches, in four replications, in which night-soil was first filled up to nearly 3 ft. at the bottom and then covered with one foot of rubbish, followed by a six inch layer of earth and half an inch cover of lime at the top. A gunny bag was then spread over lime layer and finally covered with nine inch layer of earth. Although no regular count of fly emergence was taken at that time, the general observation was that fly emergence in limed trenches was as great as in unlimed trenches. It would thus appear that lime would not prove an effective measure for controlling fly breeding.

In order of effectiveness the various treatments may be qualitatively grouped as follows :

Borax $>$ (gammexane, wood ash, DDT, earth) $>$ (bleaching powder, lime).

The daily records of development of temperature in the above treatments are given in Table III and the atomospheric temperature and humidity prevailing at the time of the experiment are also given in Table IV. It will be seen from Table III that in none of the treatments the temperature rose above 39°C., nor was there any difference in the development of temperature within the treatments. On the compost ground, however, in 25 ft. $\times$ 7 ft. $\times$ 3 ft. trenches in open, the temperature ranged between 60°C. to 65°C. on clear days during the same period of experimentation. Acharya and Rao [1945] also observed a similar lowering of temperature in experiments in jars than in trenches. This difference may be attributed to smaller mass of refuse in the tins.

A comparison of Tables I and III would thus show that the control of fly breeding in the present experiment was mainly the result of treatments and not due to any appreciable rise in temperature. A uniformly low temperature in all the tins further lends support to this view.

TABLE III

Development of temperature in compost mass in tins

Serial number	Treatments	Days after filling														Average
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	
		Temperature in °C														
1	Earth-lime cover	33·5	33·5	34·0	31·5	32·5	34·5	34·5	35·0	31·5	31·0	30·0	31·0	30·0	30·0	32·3
2	Lime cover	37·5	35·0	38·5	34·5	34·6	34·0	35·0	35·0	31·0	31·0	31·5	30·5	31·5	30·5	33·6
3	Earth-borax cover	38·0	37·5	39·5	35·0	34·0	35·0	35·0	35·0	30·0	31·5	31·5	31·5	31·0	31·0	34·0
4	Borax cover	35·0	35·0	35·5	32·5	32·0	34·0	34·0	35·0	31·0	30·5	33·5	31·5	30·5	30·5	32·9
5	Earth-bleaching powder cover	35·0	34·0	33·5	32·5	31·5	33·0	34·0	33·0	30·5	33·0	32·5	31·0	31·0	31·0	32·6
6	Bleaching powder solution spray	35·5	34·5	37·5	34·5	33·0	35·0	35·0	36·0	33·5	32·5	33·0	33·5	32·5	32·5	34·(
7	2 per cent earth-DDT cover	36·0	34·5	36·0	35·0	32·5	33·5	34·5	35·5	31·0	31·5	32·0	30·5	32·0	30·5	33·3
8	5 per cent earth-DDT cover	35·5	36·5	36·0	34·0	32·5	33·0	34·0	35·5	30·5	33·0	32·0	31·0	32·0	32·0	33·5
9	0·1 per cent earth-gammexane cover	35·5	35·0	35·5	34·0	32·0	34·0	35·0	36·0	32·0	32·0	32·0	32·0	32·5	31·5	34·5
10	0·2 per cent earth-gammexane cover	34·5	34·5	34·0	33·0	32·5	33·5	34·0	35·5	31·5	32·5	32·5	33·0	33·0	33·0	33·4
11	Wood ash cover	34·0	35·0	34·0	34·0	32·0	34·0	35·0	35·0	32·0	33·0	34·0	32·0	33·0	32·0	33·5
12	Earth-cover	35·0	36·0	35·0	32·0	34·0	35·0	35·0	34·0	34·0	31·0	33·0	32·0	33·0	..	33·8
		35·4	35·1	35·7	34·4	32·7	34·4	34·6	35·0	31·5	31·9	32·3	31·4	32·0	31·1	..

TABLE IV

Atmospheric temperature, rainfall and humidity, during the period 1-15 August, 1947 (period of experimentation).

Date	Average whole-day temperature in °C.	Percentage of average whole-day relative humidity	Rainfall in inches
1-8-47	27·5	90	0·3
2-8-47	28·0	89·5	0·27
3-8-47	29·5	85·0	0·16
4-8-47	28·5	85·0	0·05
5-8-47	28·0	87·5	0·49
6-8-47	37·0	78·0	0·01
7-8-47	30·0	87·0	0·00
8-8-47	31·5	70·5	0·00
9-8-47	27·5	98·0	1·77
10-8-47	29·0	85·0	6·00
11-8-47	29·5	84·0	1·48
12-8-47	29·5	83·0	0·63
13-8-47	28·0	91·0	0·02
14-8-47	29·0	83·5	0·02
15-8-47	30·0	80·0	0·032

EXPERIMENTS IN GLASS BOTTLES

In order to test the effect of chemicals directly on maggots, the following experiments were also subsequently conducted in (1) 250 c.c. wide mouth bottles and (2) in long specimen tubes, in duplicate, in which the maggots were brought in direct contact with the various treatments.

A small quantity of moist town refuse, about one inch thick, was put in 4 oz. wide mouth bottles, to which an inoculum of 50 maggots from night-soil, as collected in the previous experiment, was added. The various chemicals as described earlier, were then spread directly on the maggots and the mouth of the bottle covered up and tied with gently waxed mosquito netting so that only the air passed in, but the flies could not escape through the net. This experiment was repeated simultaneously in specimen tubes also in which one inch of moist fine earth was used

instead of town refuse at the bottom, and an inoculum of 20 maggots was added in this case. It was observed that the maggots developed into flies but the latter died sooner or later as they could not escape. The total number of dead flies which represented the total fly emergence, was counted in the end in each container and expressed as percentage of the total inoculum added.

The results (average of two) are expressed on percentage basis in Table V and in Table VI is presented the statistical analysis of the results obtained from experiments conducted in wide mouth bottles only, after transforming the percentages to degrees $\sin^{-1}\sqrt{p}$ where 'p' is the percentage of fly emergence. The results in specimen tubes were so apparent that they hardly needed any statistical analysis. It was also found that in the experiments conducted in specimen tubes there was a high mortality of maggots, on the whole, presumably due to change in the nature of the habitat (earth) used.

TABLE V

Effect of direct contact of chemicals on fly emergence

Serial number	Treatments	Experiments in bottles with moist refuse as substratum	Experiment in specimen tubes with moist earth as substratum
		Percentage emergence of flies	
1	Borax	0·0	0·0
2	Bleaching powder	4·0	0·0
3	DDT	39·0	0·0
4	Gammexane	56·0	2·0
5	Lime	62·0	34·0
6	Earth	62·0	15·0
7	Ash	76·0	13·0

TABLE VI

Summary of results

Serial number	Treatments	Mean Sin $-^{1}\sqrt{p}$	General mean per cent
1	Borax	0·00	0·00
2	Bleaching powder	8·20	22·10
3	DDT	38·65	104·2
4	Gammexane	49·05	132·2
5	Lime	51·95	140·1
6	Earth	51·95	140·1
7	Ash	60·85	163·4
	General mean	337·09	100·00
	Critical difference—		
	at 5 per cent	13·605	..
	at 1 per cent	19·794	..
	at 0·1 per cent	29·74	..

It will be seen from Table VI that although the results obtained in bottles are not in strict conformity with the results obtained in tins with regard to the order of effectiveness of various treatments, still the general conclusion that borax is the most effective means and lime the least so for controlling fly breeding, is confirmed from these tests also.

Further investigations are in progress on a large scale basis in trenches to find out the minimum quantity of borax required for controlling fly breeding in routine operations, as also its subsequent effect on the quality of the manure and the effect of the latter on soil and crop, along with the economics of application of borax.

SUMMARY

Effects of various chemical treatments such as lime borax, bleaching powder, DDT, grammexane, ash and earth on control of fly breeding in compost masses have been compared. Borax has been found to be the most effective method for controlling fly breeding and lime the least so.

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REPORT

SUDDEN DEATH DISEASE OF CLOVES IN ZANZIBAR*

A COLONIAL office mission, under the auspices of the Commonwealth Agricultural Bureaux paid a visit to Zanzibar to advise regarding an outbreak of Sudden death disease of cloves. The mission enquired into the possibility of controlling the disease by the use of insecticides or other measures. It may be of interest to recall here that an earlier report-keen-Nutman report has already advocated certain measures ; mainly, the felling of affected trees, to combat this menace. The assumption was that the sudden death was attributable to a virus disease and that a species of cocid was the vector to be suspected. Extracts from the report of the mission are given below. The mission consisted of J. C. Bawden, W. J. Hall, H. Martin and H. H. Storey.

The clove industry of the Protectorate of Zanzibar is seriously threatened by the disease known as Sudden death. In Zanzibar Island there is widespread devastation, and if the disease continues to spread at its present rate, there is little prospect of clove-growing industry surviving there. Already, in many districts it has probably advanced beyond the stage at which any practical control measures are possible. Fortunately, in Pemba the conditions are less extreme and the immediate application of control measures offers at least some prospect of meeting with success.

Etiology and epidemiology

Many causes, both plausible and otherwise, have been postulated for Sudden death, and it must be stressed that the cause of the disease still remains unproven. Since the start of the Clove Research Scheme many valuable data have been obtained, but unfortunately nothing, that points unequivocally to any one certain cause. The information on the epidemiology, however, does suggest most strongly that it is infectious, spread occurring largely from infected trees to their neighbours. We have examined maps and aerial photographs showing the distribution and increase of diseased trees, we have seen outbreaks from the air, and have visited many different outbreaks both in Zanzibar and Pemba. Nothing that we have seen conflicts with the view that the disease is pathogenic or suggests that any other cause is likely. This being so, in the absence of any evidence suggesting a visible pathogen, the most reasonable assumption is that Sudden death is a virus disease. This can be proved only by experimental demonstration of transmissibility. The difficulties of grafting cloves and of getting diseased material in a state suitable for use render the demonstration unusually difficult. However, some successful grafts have now been obtained, and this technique may provide the necessary evidence, though it is too early to assess the usefulness of the method yet.

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*It is a Report of the Commonwealth Agricultural Bureaux Mission to enquire into the possibilit of controlling Sudden death of Cloves by the use of insecticides or other measures.

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If Sudden deatn is a virus disease, by analogy with others it is likely to be insect transmitted. Field observations by the Clove Research team suggest that the most likely vector is a scale-insect, but again attempts to transmit from affected trees to seedlings by this insect have so far produced no results. Control measures yased on insecticidal treatments must therefore remain highly problematical until a vector has been identified. Work on transmission, both by insects and by all other possible methods, is being actively pursued and must continue to form a major part of the work of the research team until success is achieved. Results might accrue at any time, but, with virus diseases of plants much more amenable to study than the clove, the search for vectors has often been protracted, and it would be rash to expect a rapid answer for Sudden death.

In Zanzibar Island so many trees are affected and spread is occurring so rapidly that it may be too late to attempt to stay its progress. The only thing possible seems to be to let the disease run its course, planting the devastated areas either with other crops or replanting with cloves only after all standing trees over a large area have been killed or cleared. We have seen examples where replanting is proceeding in gaps and this practice, if the disease is infectious, can only be expected to perpetuate the pathogen, although many of the young trees may appear to be free from it.

In Pemba conditions are different. Although there are many outbreaks, most are still reasonably small and circumscribed. If measures to restrain the disease are postponed until its etiology has been fully elucidated, there is a great danger that the position in Pemba will come to resemble that in Zanzibar. At many outbreaks in Pemba we were able to assess the numbers of affected trees and to compare them with records made a year ago. This showed that the rate of increase varies at different places, but, on the average, the number of diseased trees has doubled in a year. At present it is reasonable to assume that, provided the disease is infectious, the rate of spread would be considerably reduced by felling affected trees. Were nothing done and the present rate of increase to continue, it would probably be impractical to attempt a cutting-out policy a few years hence.

If Sudden death is a virus disease, the sources of infection will almost certainly reside in still living trees. Unfortunately, there is no information on the period between infection and death, but, as a result of the work of the research team, affected trees can be recognized with reasonable certainty weeks or sometimes months before they wilt and die. The felling of such trees alone might go far to keep the disease within check, but some symptomless trees in contact with the affected ones will almost certainly also be infected. A much larger measure of control is likely to be achieved if contacts with affected trees are also felled, but there is not yet data on which to suggest how many contacts should be felled. This information, however, might well be obtained during the felling campaign, if it is suitably designed.

The felling campaign is likely to afford a measure of control whatever type of pathogen is involved. The only likely alternative to a virus is perhaps a fungus attacking the vascular tissues of the roots. Work so far done has failed to reveal

any such fungi, but fungal hyphae have been seen in roots of both healthy and diseased trees and their etiological significance warrants early attention.

Insect fauna of cloves

The search for a possible vector for Sudden death is handicapped by the paucity of information about the insect fauna of Zanzibar and Pemba. There are very few published records and there has been no detailed study either of the insects occurring on cloves throughout the year or of the binomics of ants and other insect fauna. Almost the only insect found by the Clove Research team is the scale provisionally identified as *Coccus hesperidum* which is attended by the *Majiya Moto* ant (*Oecophylla longinoda*).

Our visit was at the end of the dry season and the insect population was very sparse, but there was no reason to assume, as has been suggested in the past, that sudden death can be directly attributable to insect attack. Only one species, *Coccus hesperidum*, was found widely distributed on the trees. This species is world-wide and has a very wide host range ; it was seen on many plants other than cloves, in particular on citrus, both in Zanzibar and Pemba. Invariably the scale was attended by the tree nesting ant provisionally identified as *O. longinoda*. Parasitised scales were found, but it is unknown whether this or other factors accounted for the low population.

We saw nothing to conflict with the provisional hypothesis that sudden death is transmitted by the scale insect transported by the ants. The ant-nests in areas with a closed canopy are mainly at the tree tops, suggesting that the scale is carried from tree to tree by the ants through the canopy and not the undergrowth. On the other hand, in areas where die-back is common, the canopy is broken and there is considerable undergrowth in which *C. hesperidum* and other species of Coccids, Aphids and other forms of insects with sucking mouth parts were found. In such areas ant-nests were numerous in the undergrowth but rare on cloves. In this connection, it is also worth noting that Sudden death spreads more rapidly in good plantations with good stands than in the poor plantations with much die-back.

In Pemba there are many individual outbreaks, which show no apparent relation to one another. Many consist of only one or a few adjacent trees. The tree-to-tree spread in individual outbreaks is compatible with the idea of the disease being caused by a virus of which the scale is the vector. The occurrence of isolated infected trees, from which larger outbreaks later develop, is at first sight more puzzling. Two explanations can be offered. There may be alternative host from which spread occasionally occurs to clove, although there is no obvious suspect, or it may be a consequence of the method of picking. Much damage is done to the trees at picking when branches and twigs are broken. We are told that terminal branches are often carried some distance before the cloves are picked and that branches are also transported for use as fuel. The carriage of infected twigs bearing scale and ants could probably lead to contamination of trees remote from the original source.

Although we saw nothing to conflict with the hypothesis of a virus disease transmitted by *C. hesperidum*, it must be emphasised that the evidence is solely

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circumstantial. It is the prime suspect because of its general distribution on cloves and the failure to find any other likely vector, but experimental demonstration of its ability to transmit is needed before its role can safely be assumed. If a virus is responsible for sudden death, it may be one that is transmitted by an insect which rarely occurs on cloves or does so only at limited times during the year. In addition to *C. hesperidum*, a few individuals of another Coccus and a *Ceraplastes* were also found on clove trees, but nothing worthy of note was found on cloves leaves, or on the roots of the few trees examined.

Use of insecticides

The use of insecticides in controlling Sudden death depends on the disease being caused by an insect-transmitted virus. Until this has been established and the vector identified, its value is obviously speculative only. On the hypothesis that sudden death is scale transmitted, the use of insecticides has been suggested as a method of breaking the ant-scale cycle and so preventing spread. To reply on this alone would, in our opinion, be entirely misjudged. In conjunction with a cutting-out campaign, however, insecticides may have much value.

We have seen by demonstration that the application of B. H. C. dust is effective in causing *Majoya Moto* ants to leave their nests and in killing them once they have emerged. An insecticidal treatment before felling would, therefore, be valuable in preventing large numbers of ants moving with scales from felled affected trees to nearley healthy ones. In addition to dusting the trees themselves, we would also advocate dusting a swathe of ground and undergrowth around the periphery of the area of felled trees. The insecticide recommended is B. H. C. incorporated in a light dust carrier to give *circa* 0·4 per cent gamma isomer. For treating tall trees (50 ft.) a high-powered axial flow fan, mounted on a track-laying vehicle, would be desirable, but as British makes of such machines are still experimental, the use of a low power sulphur duster is recommended (see appendix to be submitted separately by H. Martin).

Given an adequate swathe treatment, a satisfactory kill of ants from nests nigh in the tall trees could be obtained by a further dusting of the fallen trees. The felled tree should be left where felled for at least a week. Dusting of trees not to be felled should be avoided as far as possible, first, because the ants thereon will be antagonistic to those from elsewhere, and secondly, because of the possible effects of B. H. C. on the quality of the harvested clove.

Further experimental work is required to find an insecticide dissimilar in action from B. H. C., either for complementary use, to prevent the possible selection of a B. H. C.—resistant ant, or for simultaneous use in a combined dust with B. H. C. Preliminary trials of 2 per cent parathion dust gave unpromising results, but pyrethrum and rotenone combinations appear to be worth further trial.

Grease-banding, either insecticidal or mechanical, seems of little value because of the number, and rough bark, of the trunks at any tree site, the unrestricted canopy and the many low-hanging branches in direct contact with undergrowth.

Control

We are deeply sensible of the heavy responsibility placed upon us by the request to assess the adequacy of control measures for a disease about which so little is known with certainty. It must rarely have happened that large-scale control measures for a disease have been attempted before the cause has been diagnosed. Nevertheless, we feel that if the future of the clove crop is to be safeguarded, some attempt to arrest sudden death is needed. The attempt may fail, but to do nothing would at present most probably lead to the loss of the clove crop in Pemba as in Zanzibar. The most that can be said with certainty is that sudden death appears to behave as though it were caused by a pathogen. Until more precise knowledge of its cause is available, it would be unwise to advocate any measures that fail to influence any type of pathogen that can reasonably be conjectured.

Hence we feel that we can do no other than support the policy of felling and that we must dispel the idea that a policy of feeling can be replaced by one of widespread use of insecticides. It cannot be too strongly emphasised that this idea rests on a chain of assumptions of which is supported by more than circumstantial evidence ; first, that sudden death is caused by a virus ; secondly that a scale insect is the vector ; and thirdly that the destruction of the *Maji ya Moto* ant would lead to the disappearance of the vector. The first is, perhaps, probable, but the same cannot yet be said of the second. It has frequently happened in virus research that the more prevalent insect on a crop is incapable of transmitting the most common virus. Finally, the third assumption is contrary to entomological experience: with the destruction of the ant, the scale may thus become more exposed to predators and the population may be reduced, but it is axiomatic that a balance will be reached between insect and predators and that the scale will not be exterminated. Thus, even if all the chain of assumptions should ultimately be established, it is still doubtful whether the use of insecticides alone would affect the control of sudden death.

We agree that, if control is to be attempted, it should rely primarily on the destruction of diseased and suspect plants. Instead of their recommendation of greaseganding trees not felled and burning the felled trees; we suggest the use of insecticides. Trees should be dusted before felling, together with an area of ground or undergrowth beyond the area. If apparatus adequate for dusting standing trees is not available, the trees should be dusted again immediately after felling.

We also recommend that, to gain information on factors affecting spread of the disease, the felling should be done in accordance with an experimental programme to be laid down by the Clove Research Scheme. We suggest, for example, that in some areas suspects only should be felled, and this treatment might be combined with dusting with B. H. C. in some outbreaks and not in others. Other treatments would consist of felling not only because of its efficacy against ants and so its direct effect, against scales, but also because it might destroy any other insect that might be a vector of sudden death. For this to be done thoroughly and the necessary data to be gathered, it will be essential that an officer should be provided who will be free from any responsibility for the actual operation of the felling and able to

devote his whole time to the mapping of outbreaks. We also recommend that certain areas should be set aside to be treated last, so that the outbreaks in them can act as controls, from which the effect of the various treatments on the rate of spread can be assessed.

A large-scale felling campaign in Pemba will take some time perhaps 1-2 years—to organise. This intervening period should be used to obtain a complete survey of all the cloves in Pemba. A partial survey has already been made, but much more detailed observations will be needed if felling is to proceed smoothly. Also, if effects of the various treatments are to be readily interpretable, the exact incidence of the disease in different areas will need to be known before any treatments are applied. Sudden death is easily identified from tne air and it would be a great help to an adequate survey if suitable aircraft could be made available when needed. Wheeled transport capable of traversing rough country is essential. The results of such a campaign conducted as an experiment should be valuable in crops other than cloves. The campaign should be flexible to permit the incorporation of lessons learnt in its early stages.

We have seen areas where clove trees have been successfully established by replanting when standing trees nearby were affected by sudden death. Nevertheless, we consider this to be a practice that should be discouraged. We would suggest that replanting with cloves should be prohibited in felled areas until such time as those operating the campaign are satisfied that the surrounding trees are free from disease.

Although we believe that the executive control of an organisation for felling diseased trees should be independent of the Clove Research team, we regard it as essential that there should be the closest collaboration at every stage with this team. This might best be attained by forming a small Advisory Committee, upon which the Director of Clove Research should serve ; this Committee would formulate policy in detail and ensure that research aspects were never overlooked. For the administration of the felling campaign we support the kind of organisation outlined in the Keen—Nutman report.

Finally, it must be stressed that at any time research may discover the cause of sudden death and this may call for the modification of the proposals we now make. Realising this, we cannot emphasise too strongly the need for research on all possible aspects of clove cultivation. So that this can be achieved, the staff of the Clove Research Scheme should be strengthened and they should not be involved in the actual felling campaign. We would also stress that the most that can be expected from a felling campaign is to halt the present alarming rate of spread. It is wishful thinking to assume that it is a 'once-for-all' treatment that will eradicate sudden death from Pemba for ever. If it achieves its end, it will still be necessary to keep a regular inspection of the crop, so that outbreaks can be noted as soon as they occur and eliminated before they have involved a large number of trees.

PRIZE

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Messrs. Gardners Corporation, New Delhi, have offered a prize of Rs. 200 per year to the best contributor of an article on 'fruit preservation and canning'. While giving this award they have selected, besides one or two other Journals, the two Journals of the Indian Council of Agricultural Research, *viz.*, Indian Journal of Agricultural Science and Indian Farming, out of which, contributors of articles on the subject have to be selected. The award has been given on an annual basis and the first award will be given to the contributor of the best article on the subject during the period 1-1-51 to 31-12-51. To adjucate articles, a Committee consisting of the following gentlemen has been formed :—

(1) Dr. V. Subrahmanyan, Director, Central Food Technological Research Institute, Mysore.

(2) Dr. Girdhari Lall, Asst. Director (Fruit Technology), Central Food Technological Research Institute, Mysore.

AND

(3) Shri Kailash Nath of Messrs. Harnarain Gopi Nath of Delhi and Hony. Secretary, All India Food Preservers' Association, Delhi.

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Reference to literature, arranged alphabetically according to authors' names, should be placed at the end of the article, the various references to each author being arranged chronologically. Each reference should contain the year of publication title of the article, the abbreviated title of the publication, volume and page. In the text, the reference should be indicated by the author's name, followed by the year of publication enclosed in brackets, when the author's name occurs in the text, the year of publication only need be given in brackets. If reference is made to several articles published by one author in a single year, these should be numbered in sequence and the number quoted after year both in the text and in the collected references.

If a paper has not been seen in original it is safe to state 'Original not seen'.

Sources of information should be specifically acknowledged.

As the *format* of the journals has been standardized, the size adopted being crown quarto (about 7⅛ in.×9⅝ in. cut), no text figure, when printed should exceed 4½ in.×5 in. Figures for plate should be so planned as to fill a crown quarto page, the maximum space available for figures being 5¾ in.×8 in. exclusive of that for letter press printing.

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